THE WATAUGA COUNTY LANDFILL
PERMIT NO. 95-02

REMEDIAL INVESTIGATION AND ALTERNATIVES REPORT

Prepared for
Watauga County
Board of Commissioners

and

North Carolina Department of Environment, Health and Natural Resources
Division of Solid Waste Management
Solid Waste Section

Prepared by
Draper Aden Associates

January 12, 1996

DAA Job No. 6520-18

Gunnar Johnsen

95-02

Gunnar Johnsen 95-02.

95-01

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January 12, 1996

Mr. Mark Poindexter
Hydrogeologist
Solid Waste Section
North Carolina Department of Environment, Health and Natural Resources
P.O. Box 27687
Raleigh, N.C. 27611-7687

RE: Watauga County Landfill, Assessment Monitoring Program,
DAA Job No. 6520-18

Dear Mr. Poindexter:

Please find enclosed two copies of the Remedial Investigation and Alternatives (RIA) Report for the Watauga County Landfill, dated January 12, 1996..

Remedial Investigation and Alternatives (RIA) Report

The enclosed report summarizes assessment and remedial investigation activities performed to date, presents a revised conceptual site model based on the results of the first year of assessment activities, discusses site remedial action alternatives, and recommends specific remedial activities to be completed at the site. Amendments to the target parameter list, per decision criteria outlined in the Assessment Plan, and withdrawal of select nonimpacted monitoring wells are proposed for NCDEHNR approval at the conclusion of Section IV.

The RIA Report concludes with a discussion of remedial action alternatives. A remedial cap is proposed as an immediate remedial action for NCDEHNR review and approval. The proposed remedial action focuses on source containment, as established by the EPA's presumptive remedy directive (EPA 540-F-93-035, September 1993).

If you should have any questions or comments concerning the enclosed report or upcoming Assessment activities, please do not hesitate to contact me.

Sincerely,
DRAPER ADEN ASSOCIATES

Jeffrey E. Smith
Project Geologist

JES/rc
Attachments

cc: Mr. James S. Ratchford, Watauga County Manager
Mr. Richard M. DiSalvo, Jr., P.E., Principal, DAA
Mr. Scott Kroll, P.E., Environmental Program Manager, DAA
Mr. Justin E. Babendreier, Director of Technical Services, DAA
Mr. William D. Newcomb, P.G., Groundwater Project Manager, DAA

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Executive Summary

On July 7, 1993, Watauga County and the North Carolina Department of Environment, Health, and Natural Resources (NCDEHNR), Division of Solid Waste Management, Solid Waste Section entered into a Consent Agreement under which the County agreed to take steps to determine the status of groundwater and surface water quality at and in the vicinity of the Watauga County Landfill. Pursuant to the Consent Agreement, Watauga County submitted the Watauga County Landfill Assessment Plan (dated September 3, 1993), prepared by Draper Aden Associates, to the NCDEHNR. The Assessment Plan was approved by the NCDEHNR on September 30, 1993, and Draper Aden Associates has conducted the assessment subject to the state's oversight and approval.

Initial Assessment field activities were detailed in the Watauga County Landfill Activity Report (dated July 29, 1994). The four quarterly background assessment monitoring events were performed on the upgraded groundwater and surface water monitoring network (comprised of 18 wells and 5 surface water locations) between June, 1994 and April, 1995. Background monitoring results are detailed in four separate Assessment Monitoring Results Reports (dated November 2, 1994, February 17, 1995, August 3, 1995, October 9, 1995).

The analytical results obtained from the four assessment background monitoring events indicate the detection of organic compounds in the Watauga County Landfill monitoring network is limited to groundwater and surface water monitoring locations existing south of the proposed Route 421 bypass (see Figure 1). The background analytical results indicate no confirmed elevated detections in the four monitoring wells located north of the proposed bypass. Organic compounds were observed in the west and north drainages below the landfill and along the southern saddle between the landfill and the Rocky Mountain Heights Subdivision.

The Watauga County Landfill Assessment Plan specifies that upon review and evaluation of the four background data sets, a Remedial Investigation and Alternatives (RIA) Report will be prepared and submitted to the NCDEHNR for review and comment. The following RIA Report summarizes assessment and remedial investigation activities performed to date, presents a revised conceptual site model based on the results of the first year of Assessment monitoring activities, discusses site remedial action alternatives, and recommends specific remedial activities to be completed at the site. Amendments to the target parameter list, per decision criteria outlined in the Assessment Plan, and withdrawal of select non-impacted assessment monitoring wells from routine, semi-annual groundwater monitoring are proposed herein for NCDEHNR approval.

A remedial cap is proposed as an immediate remedial action for NCDEHNR review and approval. The proposed remedial action focuses on source containment, as established by the EPA's presumptive remedy directive (EPA 540-F-93-035, September 1993). Based on an evaluation of remedial alternatives, Draper Aden recomends the following package of remedial actions: source containment, implemented through a remedial cap, supplemented by risk assessment, institutional controls, natural attenuation, and continuing assessment investigation. The proposed remedial cap will reduce infiltration into the disposal area by a minimum thirty-five times that allowed by the approved regulatory cap.

water supplied by Boone

Additional risk assessment activities will address exposure pathways outside the source area. These activities include the provision of potable water via the extension of public water along the existing Route 421 alignment, coupled with continued assessment monitoring activities. Response actions for exposure pathways outside the source area will be combined with the presumptive remedy to develop a comprehensive site response.

The remedial cap as proposed consists of a 40 mil Linear Low Density Polyethylene membrane provided with appropriate bedding, drainage and cushion layers. General specifications of the proposed cap are discussed at the conclusion of the RIA Report. Detailed cap specifications will be submitted for NCDEHNR review upon approval of the proposed remedial cap as provided herein..

Construction of the cap will require design of the cap and procurement of a contractor. The proposed implementation schedule may be summarized as follows:

Public Participation Session	January 16, 1996
Public Comment Period Ends	January 26, 1996
Board of Commissioners Consideration	February 5, 1996
Completion of Proposed Remedial Design	February 8, 1996
DEHNR Approval	February 8 - March 1, 1996
Advertisement and Bid	March 1 - March 30, 1996
Award of Contract	April 1 - April 15, 1996
Construction	April 16 - August 31, 1996

Because of the severity of weather in the Watauga County area, it is critical to initiate the construction as soon as possible this spring. Timely approval of this remedial option will help facilitate implementation.

I. INTRODUCTION

On July 7, 1993, Watauga County and the North Carolina Department of Environment, Health, and Natural Resources (NCDEHNR), Division of Waste Management, Solid Waste Section entered into a Consent Agreement under which the County agreed to take steps to determine the status of groundwater and surface water quality at and in the vicinity of the Watauga County Landfill (Figure 1 is a Vicinity Map depicting the location of the Watauga County Landfill and the near vicinity). Pursuant to the Consent Agreement, Watauga County submitted the <u>Watauga County Landfill Assessment Plan</u> (DAA, September 3, 1993), prepared by Draper Aden Associates, to the NCDEHNR.

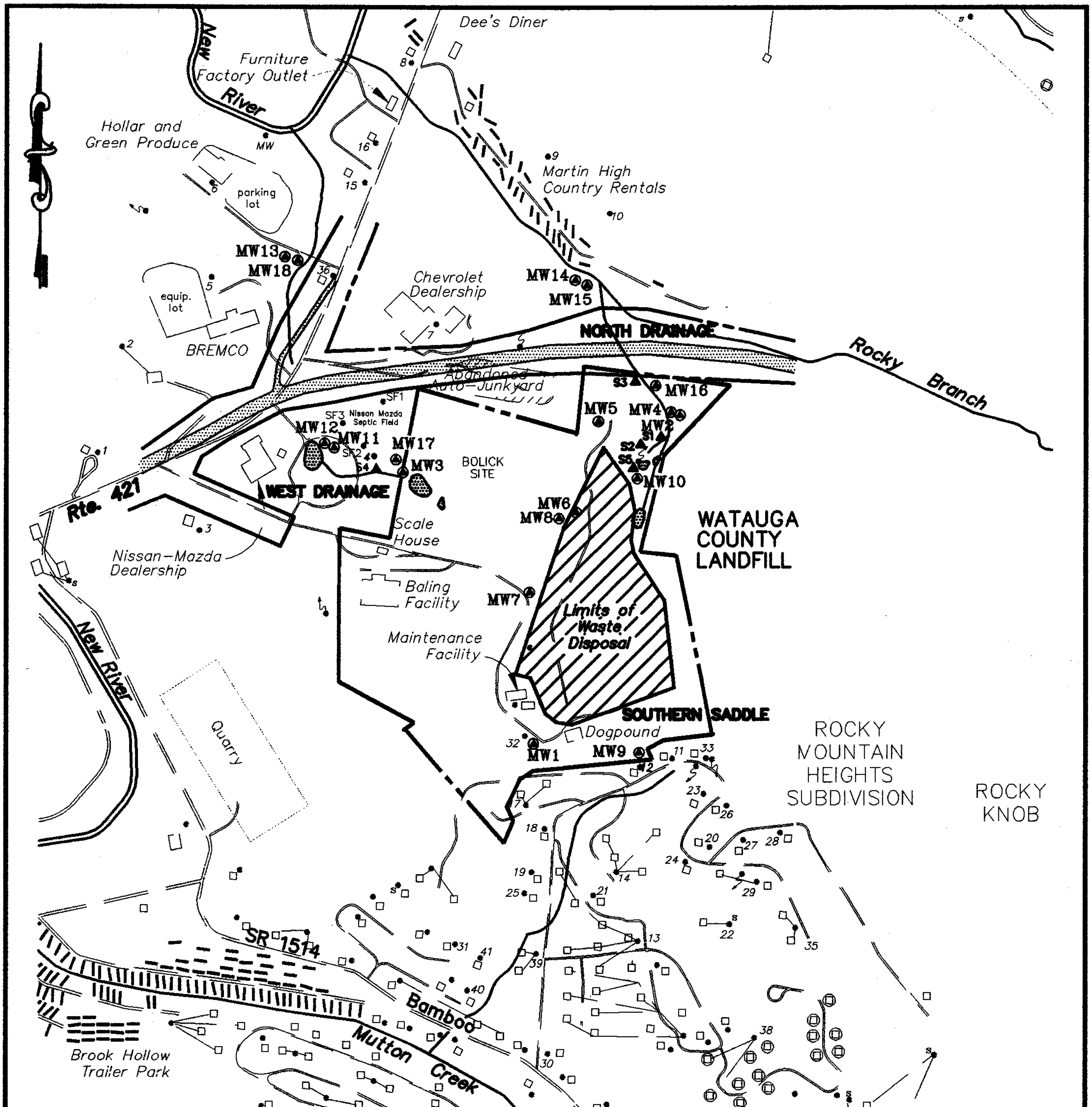
Four independent quarterly background assessment monitoring events were performed on the upgraded groundwater and surface water monitoring network (comprised of 18 wells and 5 surface water locations) between June, 1994 and April, 1995. The Watauga County Landfill Assessment Plan specifies that upon review and evaluation of the four background data sets, a Remedial Investigation and Alternatives (RIA) Report will be prepared and submitted to the NCDEHNR for review and comment.

1.1 Remedial Investigation and Alternatives

The objective of the enclosed Remedial Investigation and Alternatives (RIA) Report is to summarize assessment and remedial investigation activities performed to date at the Watauga County Landfill, review remedial alternatives, and propose immediate remedial action responses appropriate for implementation at this time. The RIA Report presents a revised conceptual site model based on the results of the first year of assessment monitoring. The presentation of the revised conceptual site model primarily involves discussions concerning target parameter distributions and related hydrogeologic investigations.

Remedial alternatives are reviewed for the site based on the revised Conceptual site model, with severe limitations noted for most invasive remedial actions. The site characteristics described in the following sections (i.e. size of the facility, composition of impacted aquifer mediums, nature and distribution of organic constituents, etc.), severely limit the effectiveness of either ex-situ or in-situ stimulated remediation. A remedial action focusing on source containment, supplemented by risk assessment, institutional controls, natural attenuation, and continuing investigation of certain issues is proposed.

A remedial cap is proposed as an immediate remedial action for NCDEHNR review and approval. This proposed remedial action focuses on source containment, as established by the EPA's presumptive remedy directive for municipal landfill sites (EPA 540-F-93-035, September 1993), contained herein Appendix III. EPA's presumptive remedy directive is consistent with guidance from Section 300.430(a)(iii)9(B) of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), which contains the assumption



LEGEND

- Stream
- Pond
- Existing Residence/Multi-unit Residence
- Existing Mobile Home
- Assessment Monitoring Wells
- Surface Water Sampling Locations
- SF1 Septic Field Monitoring Wells
- Spring
- s Spring Used as Potable Water Source
- 2 Existing Potable Well/Sampled Well Ref. No.
- Proposed Rt. 421 Improvements
- Proposed Rt. 421 Right-of-Way

MW-1, MW-2, MW-3, AND MW-4 COMPRISE THE ORIGINAL MONITORING NETWORK.

MW-5, MW-6, AND MW-7 WERE INSTALLED IN AUGUST, 1992.

MW-8 THROUGH MW-18 WERE INSTALLED IN JANUARY AND FEBRUARY, 1994 TO COMPLETE THE CURRENT ASSESSMENT MONITORING WELL NETWORK.

– MONITORING POINTS EXCEEDING FEDERAL DRINKING WATER STANDARD MAXIMUM CONTAMINANT LEVELS (EPA 822-R-94-001).

VICINITY MAP
WATAUGA COUNTY LANDFILL
WATAUGA COUNTY, NORTH CAROLINA

Job No.: 6520-18
Scale: NOT TO SCALE
Date: 15 Dec 95

FIGURE 1

Draper Aden Associates
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Blacksburg, VA – Richmond, VA – Nashville, TN

65200.DWG

that engineering controls, such as containment, will be used for situations where treatment is impracticable. The EPA generally considers containment to be the appropriate response action, or "presumptive remedy,' for the source areas of municipal landfill sites.

Appendix A of the EPA Presumptive Remedy Directive (included in Appendix III herein) states: "...analysis that EPA conducted of feasibility study (FS) and Record of Decision (ROD) data from CERCLA municipal landfill sites led to the establishment of containment as the presumptive remedy for these sites. The objective of the study was to identify those technologies that are consistently included in the remedies selected, those that are consistently screened out, and to identify the basis for their elimination. Results of this analysis support the decision to eliminate the initial technology identification and screening steps on a site-specific basis for this site type. The technical review found that certain technologies are appropriately screened out based on effectiveness, implementability, or excessive costs."

The remedial cap will reduce the amount of water that is infiltrating into the waste disposal area, thereby reducing the driving force mobilizing the contaminants trapped in the waste. Modeling of infiltration rates utilizing the EPA HELP Model, Version 3, indicates the cap design, as detailed in Section VII of this RIA report, will prevent approximately 12 million gallons of water per year from infiltrating into the 20 acre waste disposal area. Reducing 12 million gallons from entering the disposal area will assist greatly in containing the source.

Upon approval and implementation, the proposed remedial action will continue to be evaluated on the basis of additional monitoring information collected during the Assessment Monitoring Program. Modifications to the assessment program and remedial investigation activities (i.e. installation/withdrawal of monitoring wells, addition/deletion of target parameters) are proposed herein, based on background assessment monitoring results and the revised conceptual site model.

Based on an evaluation of remedial alternatives, the most cost effective and technically justified remedial action proposed for this site is containment, supplemented by a risk assessment, institutional controls, natural attenuation, and continuing investigation of certain issues. Site conditions preclude the use of active or invasive remedial activities. Assuming risks are identified and mitigated, source containment and natural attenuation are the most effective solutions to environmental impacts at the site.

Target parameter concentration and distribution trends observed during background assessment monitoring indicate that steady state conditions are predominant across the site. The steady state conditions observed thus far suggest that no more contaminants are entering the groundwater from the waste disposal area than are naturally attenuating as the groundwater approaches the Route 421 bypass. Migration of detectable concentrations of the target parameters beyond the current boundary is not anticipated. Although the current assessment background monitoring data does not allow an adequate additional assessment monitoring in the coming years will provide the temporal data to properly assess contaminant transportation, migration, and fate trends. Continued modeling of the site will utilize Draper Aden Environmental Modeling's (DAEM) services to assist remedial investigations, risk assessment, and site management.

Capping of the disposal area will assist in diminishing leachate production, and thus contaminant migration. Natural attenuation processes will assist in lowering the concentrations of the target parameters, and with source controls in place, should provide for continuously diminished contaminant concentrations.

1.2 Initial Assessment Activities

The Assessment Plan was approved by the NCDEHNR on September 30, 1993. An Assessment Activity Report (July 29,1994) presented the findings of the initial activities conducted under the approved Assessment Plan. The report also identified future monitoring activities and other areas of continued investigation. The initial field activities as defined in the Assessment Plan included the following:

- Landfill Cover Depth Verification,
- Landfill Gas Screening,
- Off-Site Assessment Monitoring Well Access and Easement Development,
- Assessment Monitoring Well Drilling Services Bid Procurement,
- Assessment Monitoring Well Drilling and Installation,
- Health and Safety Monitoring,
- Well Development,
- Aquifer Testing,
- Dedicated Pump Installation, and
- Laboratory Analytical Services Bid Procurement.

Section II of the Activity Report presented the results of the above initial field activities. A discussion concerning initial field activities is presented in Section III herein.

Approval of the Assessment Plan by the NCDEHNR was subject to the condition that, in addition to activities defined by the plan, further investigation would be conducted in the following two areas:

- the relationship between the fracture trace lineament and the formation contact between the Lower Precambrian amphibolite/hornblende gneiss and the Lower Precambrian "mixed rock" (primarily focusing on ascertaining the possible existence of a preferential flow path trending southward along the contact or lineament).

- suitability of spring locations along the formation contact and/or the tributary of Mutton Creek in the Rocky Mountain Heights Subdivision for addition to the surface water sampling program.

Section II of the Activity Report also provided an updated discussion on the geology and hydrogeology of the site. Information obtained from assessment well drilling, aquifer testing, and site reconnaissance was applied to refining the current assessment of geologic formation contacts, fracture trace lineaments, and spring occurrence across the site. A revised Geology Map and Groundwater Potentiometric Surface Map incorporating information obtained from these assessment investigations was also provided. The following section of the RIA Report presents an overview of the geology and hydrogeology of the site and provides a detailed discussion concerning assessment geologic and hydrologic investigations

The Activity Report also presented a one page summary of the "New River Sediment Study", a three month-long geochemical study of the landfill drainage sediments, conducted by Dr. John Callahan of the Appalachian State University (ASU) Geology Department. The "New River Sediment Study" was sponsored in part by Dr. Harvard Ayers, Dr. Brad Batchelor, Rhonda Sechrest, and the Watauga Chapter of the Blue Ridge Environmental Defense League (BREDL). The Activity Report summarized information obtained from an article in The Mountain Times, April 28, 1994 concerning the study. The sediment study investigated the levels of thirty-one (31) metals in the stream sediments at sixteen (16) stream sites draining the Watauga County Landfill, and other areas in the New River drainage basin in and around the town of Boone. The sediment study found no evidence of heavy metal pollution in the sediments of streams draining the area of the Watauga County Landfill.

1.3 Background Assessment Monitoring Results

The first quarter background assessment monitoring event for the upgraded groundwater and surface water monitoring network (comprised of 18 wells and 5 surface water locations) was performed in June, 1994 and the final fourth quarter background assessment monitoring event was conducted in April, 1995. Background monitoring event results are detailed in four separate Assessment Monitoring Results Reports (dated Nov. 2, 1994, Feb. 17, 1995, Aug 3, 1995, and Oct. 9, 1995). A short summary of the analytical results obtained during initial background data collection activities is provided below. A detailed discussion of background assessment monitoring analytical results is presented in Section IV herein.

The analytical results obtained from the four assessment background monitoring events indicate the detection of organic compounds in the Watauga County Landfill monitoring network is limited to groundwater and surface water monitoring locations existing south of the proposed Route 421 bypass (see Figure 1). The background analytical results indicate no confirmed elevated detections in the four monitoring wells located north of the proposed bypass. Organic compounds were observed in the west and north drainages below the landfill and along the southern saddle between the landfill and the Rocky Mountain Heights Subdivision.

West Drainage - In the west drainage, the detection of organic compounds above groundwater standards was observed in both the soil and bedrock aquifer media. Two organic compounds were found above surface water standards at the surface water sampling location in the west drainage.

North Drainage - In the north drainage, the detection of organic compounds above groundwater standards was only observed in the bedrock aquifer medium. The recent analytical results indicate no significant concentrations of organic compounds in the soil aquifer medium. Lower concentrations of organic compounds were detected in the two surface water sampling locations directly below the disposal area in the north drainage. No concentrations of organic compounds were confirmed present in the north drainage surface water at the landfill property boundary.

Southern Saddle - Several organic compounds detected in the monitoring well located along the saddle between the landfill and the Rocky Mountain Heights subdivision were observed at markedly different concentrations than the levels of the organic compounds detected in the remainder of the monitoring well network. In addition, several different organic compounds were detected along the saddle between the landfill and the Rocky Mountain Heights subdivision that were not detected in the remainder of the monitoring well network.

In response to the NCDEHNR's recommendation to examine the suitability of spring locations along the formation contact and/or the tributary of Mutton Creek in the Rocky Mountain Heights Subdivision for addition to the surface water sampling program, the spring located along the base of Rocky Knob, adjacent to the landfill, was also sampled and analyzed, resulting in no organic compounds detected.

The distribution trends of the analytical results obtained from background assessment monitoring events indicates that the aquifer system may be attaining steady-state conditions. The analytical results indicate that the concentrations of target organic parameters within the groundwater appear to be naturally attenuating or diminishing along the frontal edge of the organic plume.

1.4 Residential/Commercial Well Monitoring Program

Concurrent with the landfill groundwater and surface water sampling program, a total of 41 residential and commercial use potable wells in the vicinity of the landfill have also been sampled and analyzed. The initial residential and commercial potable water well sampling event was conducted by Draper Aden Associates on March 5, 1993 at the direction of Watauga County and with approval of State officials. An ongoing potable water well sampling and analysis program is currently being jointly conducted by the Appalachian District Health Department and the North Carolina State Laboratory of Public Health.

The analytical results of the residential and commercial potable water well sampling and analysis program indicate that two of the forty-one sampled potable wells detected organic compounds above drinking water standards. These two wells are the Carroll residence well, located in the Rocky Mountain Heights Subdivision (along the southern saddle), and the Nissan-Mazda Dealership well, located in the vicinity of the intersection of Rt. 421 and Landfill Road (within the west drainage). The source of contamination in the wells has not yet been determined and is still being investigated. Many of the detected compounds have not been detected in the groundwater monitoring wells within the landfill property boundaries. The *impacted* residence and the business have been connected to the Town of Boone water system.

Further discussion on the residential and commercial potable water well sampling and analysis program analytical results is presented in Section V herein.

1.5 Ongoing Assessment Monitoring Activities

The first comprehensive assessment monitoring event was recently performed on the upgraded monitoring network in July, 1995. This monitoring event utilized low level risk assessment (LLRA) screening methods to analyze groundwater samples for 195 organic compounds and 18 metals included in the comprehensive EPA Appendix II list (40 CFR Part 258). The parameter list for this monitoring event is identical to the parameter list for the initial assessment monitoring event, conducted by Draper Aden Associates on the Watauga County Landfill's original four (4) monitoring well network on March 5, 1993. Review of the recent comprehensive analytical data set indicates similar organic compound distribution trends as observed in previous background monitoring events. A comprehensive report of these results will be available concurrent with the Remedial Investigation Report herein.

The second semi-annual assessment monitoring event (sixth assessment event) is tentatively scheduled to be performed by Draper Aden Associates in January, 1996. As indicated in the Assessment Monitoring schedule (Table 1, Appendix I), assessment monitoring wells and surface water monitoring points will be analyzed utilizing CLP analytical methods for the second semi-annual assessment monitoring event. Appropriate modifications to the assessment program and remedial investigation applicable to the second semi-annual assessment monitoring event are proposed herein. The review of assessment analytical data sets concludes with amendments to the target parameter list (Section 4.8.5), per decision criteria outlined in the Assessment Plan. Withdrawal of select non-impacted assessment boundary monitoring wells are also proposed at this time.

Continued modeling of the site will utilize Draper Aden Environmental Modeling's (DAEM) services to assist remedial investigations and risk assessment. DAEM produces complex state-of-the-art numerical models for fate and transport of contaminants. Models will be applied to optimize site characterization and minimize the cost of data collection efforts involved with assessing subsurface conditions

In an effort to keep the community informed of the activities associated with the Assessment Monitoring Program, Watauga County has continued to make current Activity and Monitoring Reports available for public review both in the Watauga County Courthouse and the Watauga County Public Library. Interested parties can contact either location to inquire about reviewing specific documents.

II. SITE GEOLOGY AND HYDROGEOLOGY

The following section presents an overview of the geology and hydrogeology of the site and provides a detailed discussion concerning assessment geologic and hydrologic investigations.

2.1 Regional Geology

Watauga County resides in the Blue Ridge belt geologic province in northwestern North Carolina. The Blue Ridge belt is composed primarily of 1,000-million to 1,100-million-year-old metamorphic and plutonic rocks. Near the southeastern edge of the Blue Ridge belt, the metamorphic bedrock has been thrust many miles northwestward across unmetamorphosed Cambrian sedimentary rocks.

In southwestern Watauga County, the Blue Ridge thrust sheet is breached by erosion, and the rocks beneath are exposed in the Grandfather Mountain window. The Blue Ridge thrust sheet surrounding the Grandfather Mountain window consists largely of schist, gneiss, and amphibolite and of Cranberry Gneiss. The schist, gneiss, and amphibolite were derived by metamorphism of sedimentary and volcanic rocks and the Cranberry Gneiss is a complex of migmatitic and granitic rocks which underlies the metasedimentary and metavolcanic rocks. The schist, gneiss, and amphibolite and the Cranberry Gneiss probably formed during the same metamorphic episode.

The rocks of the Blue Ridge thrust sheet moved northwestward at least 35 miles over the Grandfather Mountain window after the close of metamorphism 350 million years ago. Left-lateral strike-slip movement greater than 135 miles was concurrent with, but may have lasted somewhat longer than, thrusting. Mineral lineation, layering and foliation in rocks of the Blue Ridge thrust sheet are generally subparallel to the fault structures originating from the thrusting. These structures are found to dip away from the Grandfather Mountain window on all sides and broad flexures in these structures plunge away from its northwest and northeast corners (Bryant and Reed, 1970).

2.2 Site Specific Geology

Within the context of the regional geologic mapping by Bartholemew and Lewis, the Watauga County Landfill is located within an assemblage of metamorphic and plutonic rocks referred to as the Watauga Massif. This regional geologic map depicts the Cranberry-Mine Layered Gneiss and small intrusion of late Precambrian plutonic rocks mapped as granitoids immediately southeast of the Town of Boone, North Carolina (Bartholemew and Lewis, 1984). This body of plutonic rocks is not included in more detailed mapping conducted by Bryant and Reed as depicted in Figure 5 of the Assessment Plan. An assemblage of a diverse group of rocks transitional between predominantly amphibolitic rocks and predominantly granitic Cranberry gneiss have been mapped by Bryant and Reed in a narrow belt that approximates the shape and orientation of the plutonic granitoid body depicted on the geologic map compiled by Bartholemew and Lewis.

This assemblage is mapped and referred to by Bryant and Reed as "mixed rocks". The "mixed rocks" assemblage is a narrow band less than one half mile wide between the low grade metamorphic rocks of the layered cataclastic Cranberry gneiss and the tectonically overlying medium grade amphibolite and hornblende gneiss. The mixed rocks consist of interlayered and intergrading amphibolite calc-silicate granofels, biotite-hornblende gneiss, hornblende-epidote-biotite gneiss, biotite-hornblende-plagioclase schist and gneiss, epidote-biotite-plagioclase schist and gneiss, and granitic gneiss ranging from quartz diorite to quartz monzonite. These rocks are mapped as a unit, the contacts of which are drawn at the first occurrence of layers of granitic rock in the amphibolitic on one side, and the place where granitic layers become dominant on the other side.(Bryant and Reed, 1970).

All of the components of the mixed rock are of medium metamorphic grade and probably originated through incipient and local feldspathization of rocks similar to the adjacent amphibotite. Most, if not all of the strongly developed layering within the mixed rocks has been produced by shearing of migmatitic layering. The most strikingly layered rocks are the most sheared. Less sheared rocks are generally more granitic and have a migmatitic aspect. The mixed rocks appear to be a gradation zone between migmatitic Cranberry Gneiss and schist, gneiss, and amphibolite, all of which were subsequently metamorphosed.(Bryant and Reed, 1970).

The mapped contact between the "mixed rocks" and the predominantly amphibolitic rocks is located directly beneath the Watauga County Landfill trending along a series of previously documented springs that have subsequently been buried by landfill activities. This contact trends in a northwesterly direction along the central drainage of the Bolick site and trends in a southwesterly direction along the toe of the slope of Rocky Knob, located above the Rocky Heights Subdivision (see Figure 3 herein). The contact along the toe of the slope of Rocky Knob is again characterized by a series of springs.

2.3 Hydrogeology

2.3.1 Surface Water

The Watauga County Landfill site resides within the watershed of the South Fork of the New River. The area of the watershed potentially influenced by the site is comprised for the following three (3) primary drainages:

- the unnamed tributary of Rocky Branch located directly below the surficial drainage of the fill area (herein referred to as the north drainage),
- the unnamed drainage located below the Bolick Site (west drainage) and,
- the unnamed tributary of Mutton Creek located within the Rocky mountain Heights subdivision

The unnamed tributary of Rocky Branch is the only drainage directly influenced by surface flow from the fill area. Evidence indicates that groundwater beneath the landfill is discharged from the fractured bedrock aquifer to the unconfined soil aquifer within the watersheds of the west and north drainages.

2.3.2 Groundwater

Two primary aquifer systems exists beneath the Watauga County Landfill property, an unconfined soil aquifer and a fractured bedrock aquifer. The fracture system aquifer extent is likely governed by its global geometry within the regional bedrock. The continuous nature of core fracture zones within the regional bedrock dictates the aquifer system's extent. The fracture system aquifer appears to possess considerable lateral and vertical extent, although locally concentrated in several core regions. Some of the groundwater from the fracture system is discharged to the soil at lower elevations where it eventually migrates to the South Fork of the New River and its tributaries.

Within the fractured bedrock, a succession of interconnected discontinuities supply groundwater at various depths. Wells installed within these fracture systems have documented water production zones occurring at variable depths from 40 to 400 feet from the surface. The primary permeability of the unfractured metamorphic rock is likely <2%. Because of the pressures of the overlying bedrock, fracture occurrence and permeability generally decrease with depth.

A review of over sixty wells installed within the bedrock aquifer system in the vicinity of the site reveals that greater then 90% of the wells encountered sufficient water production zones before reaching depths of 200 feet from the ground surface. Although some wells were drilled to total depths of 500 to 600 feet from the surface, few wells access water production zones beyond 400 feet in depth. Attempts to install some of the wells in the vicinity of the site have not encountered sufficient water production zones after reaching depths of 500 to 600 feet from the surface.

Wells installed in both the fracture and soil aquifer systems reveal that the potentiometric surface is similar at different aquifer depths. The shared potentiometric surface suggests that soil and fracture water production zones may be somewhat interconnected by hydraulically conductive fractures, joints, and/or shear zones. The discontinuities within the bedrock owe their origin to stresses related to thrust faulting and therefore are not likely to be horizontally oriented although they may have a rather continuous lateral extent. The resulting fracture flow directions are not necessarily the flow directions suggested by the potentiometric flow gradient, but rather by flow patterns determined by fracture orientation. These flow patterns, can however, be generally predicted by overall drainage characteristics of the area. The shared potentiometric surface of the soil and fracture aquifer system is presented in Figure 4.

2.4 Assessment Geologic and Hydrogeologic Investigations

Geologic and hydrogeologic mapping of the Watauga County Landfill and vicinity was refined from the previous Assessment Plan mapping by utilizing information gained through assessment drilling and site reconnaissance. The following discussion summarizes the refined hydrogeologic model of the site.

2.4.1 Site Geology

2.4.1.1 Geologic Formation Contacts

Geologic formations encountered during the drilling of the additional eight (8) bedrock assessment wells generally agree with expected formations as depicted on the geologic map compiled by Bryant and Reed (1970) and presented on Figure 5 in the Assessment Plan.

Rock encountered during the drilling of four (4) of the assessment wells installed in bedrock, MW-8, MW-9, MW-12, and MW-17, appears to be the rock assemblage referenced by Bryant and Reed as Lower Precambrian "mixed rocks" (pm). The "mixed rocks" assemblage is a narrow band, less than one half mile wide, existing between a low grade layered cataclastic schist and gneiss and a tectonically overlying medium grade amphibolite and hornblende gneiss. The "mixed rocks" unit, as described by Bryant and Reed, consists of interlayered and intergrading amphibolite calc-silicate granofels, biotite-hornblende gneiss, hornblende-epidote-biotite gneiss, biotite-hornblende-plagioclase schist and gneiss, epidote-biotite-plagioclase schist and gneiss, and granitic gneiss ranging from quartz diorite to quartz monzonite.

Monitoring wells, MW-10 and MW-18, encountered the Lower Precambrian amphibolite and hornblende gneiss (pa). These rocks tectonically overlie the "mixed rock" assemblage.

water flows through the whole unit & not just through discrete fractures

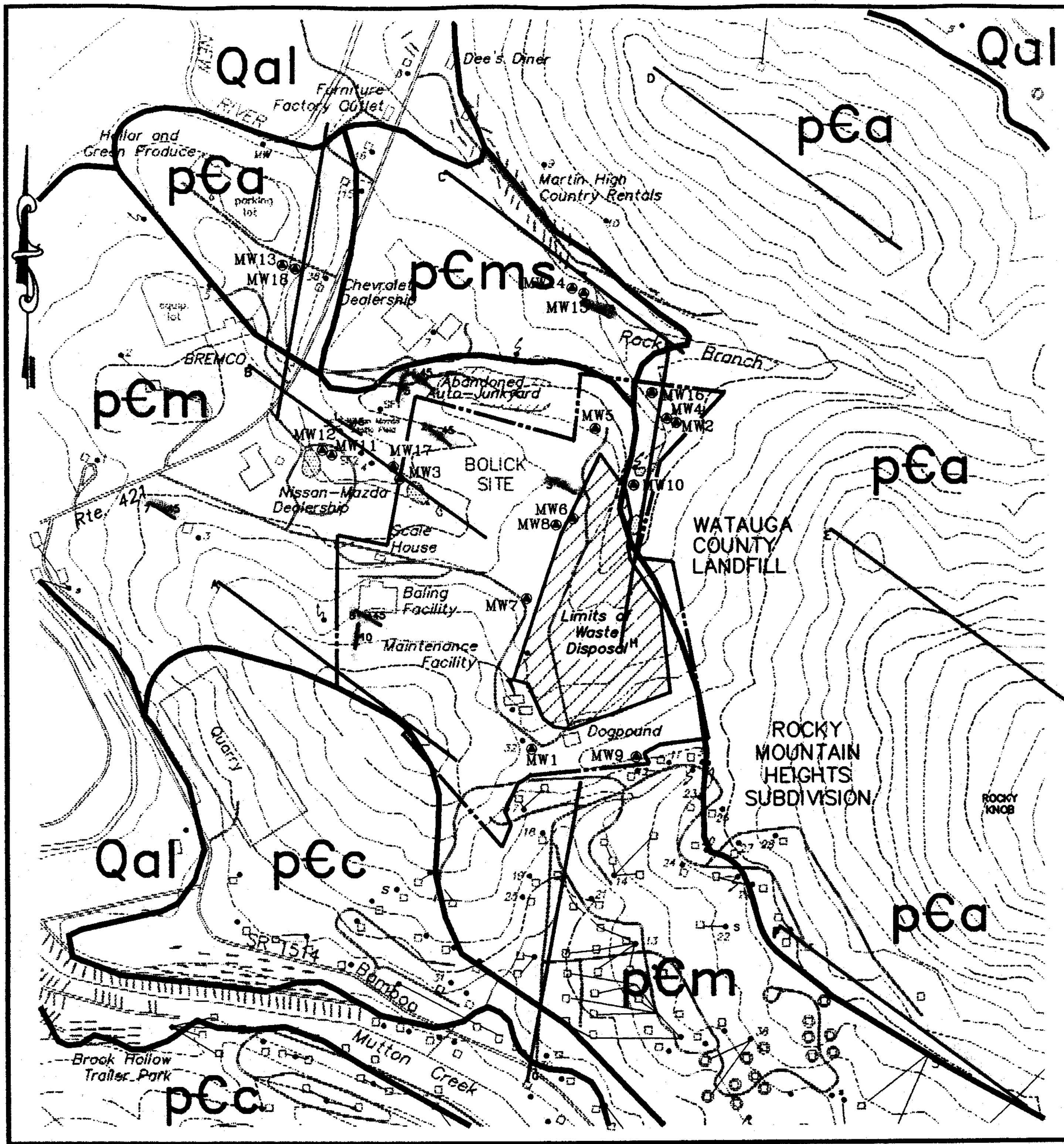
An exception to Bryant and Reed's generalized mapping was encountered in monitoring wells, MW-14 and MW-15, where approximately seventy (70) feet of the lower Precambrian biotite-muscovite schist and gneiss (pms) was encountered above the amphibolite and hornblende gneiss. The observed stratigraphic relationship refines Bryant and Reeds' mapping and is supported on the generalized cross section included on Figure 5 of the Assessment Plan and Figure 3 herein. Bryant and Reed's legend depict these two units as coexisting and Bryant and Reed provide the following statement as to why the two assemblages were not separated: the "mappable amphibolite units are intimately interlayered with the micaceous rocks" and the "mapping of contacts... is therefore extremely subjective in many areas". The presence of the biotite-muscovite schist and gneiss in the vicinity of monitoring well, MW-14 and MW-15 is supported as well by the Watauga County Soil Survey (USDA SCS, 1944), which depicts residual soils of weathered mica schist and gneiss in this vicinity.

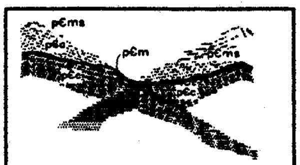
tighter w/ discrete fractures

A revised Geology Map (Figure 3) is enclosed. The revised mapping incorporates information obtained from the recent drilling and site reconnaissance with information obtained from Bryant and Reed (1970) and the Watauga County Soil Survey (1944).

Refinements to Bryant and Reed's regional geologic mapping primarily involve the identification of pockets of biotite-muscovite schist and gneiss lenses existing above the amphibolite and hornblende gneiss. These micaceous lenses are preferentially distributed in the topographically low regions mapped as amphibolite and hornblende gneiss by Bryant and Reed (1970). Less prone to weathering and erosion relative to the mica schist and gneiss, the amphibolite and hornblende gneiss tend to occupy the topographical high areas of this region.

Alluvial deposits and residual micaceous soils are depicted on the Watauga County Soil Survey further to the north-northwest of the biotite-muscovite schist and gneiss, as depicted on the revised Geology Map. Recent reconnaissance failed to confirm the presence of the mica schist and gneiss bedrock further to the north-northwest of the biotite-muscovite schist and gneiss, as depicted on the revised Geology Map. Revisions to the geology map avoided soil survey inferences which could not be verified in the field. The presence of these micaceous residual and alluvial soils suggest that further refinements of the geologic model may result from future study.





Generalized Cross Section

N 10° E

Macroscopic Linear Features A–I

N 58° W

Microscopic Linear Features 1–7 (Layering, Foliation, Joints)

pЄms Lower Precambrian biotite–muscovite schist and gneiss
pЄa Lower Precambrian amphibolite and hornblende gneiss
pЄm Lower Precambrian "mixed rock" containing interlayered and intergrading amphibolite calc–silicate granofels, biotite–hornblende gneiss, hornblende–epidote–biotite gneiss, biotite–hornblende–plagioclase schist and gneiss, epidote–biotite–plagioclase schist and gneiss, and granite gneiss
pЄc Lower Precambrian Cranberry gneiss "layered cataclastic gneiss"
Qal Flood–Plain Alluvium

COMPILED FROM: BRYANT & REED (1970), THE WATAUGA COUNTY SOIL SURVEY (1994), AND FIELD OBSERVATIONS

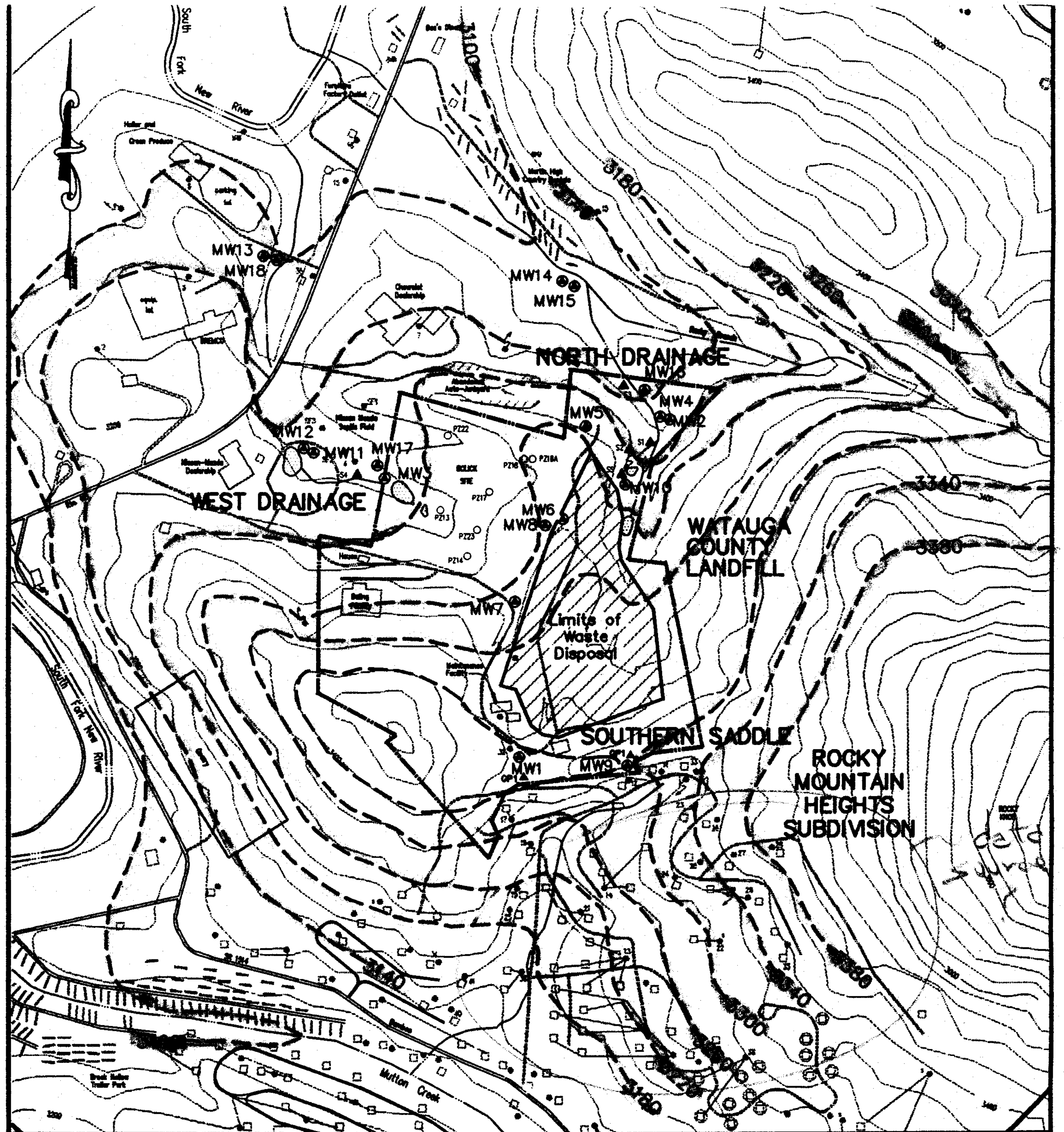
REVISED GEOLOGY MAP
WATAUGA COUNTY LANDFILL
WATAUGA COUNTY, NORTH CAROLINA

Job No.: 6520–14
Scale: NOT TO SCALE
Date: 10 JUN 94

FIGURE 3

Draper Aden Associates
CONSULTING ENGINEERS
Blacksburg, VA – Richmond, VA – Nashville, TN

6520C.DWG



LEGEND

Stream

Overhead Power

Existing Ground

Pond

Existing Residence/Multi-unit Residence

Existing Mobile Home

Assessment Monitoring Wells

Surface Water Sampling Locations

GP1 Gas Monitoring Well

Groundwater Potentiometric Elevation (Inferred from static water level data obtained on April 11-13, 1995)

SF1 Septic Field Monitoring Wells

Spring

S Spring Used as Potable Water Source

2 Existing Potable Well/Sampled Well Ref. No.

correlates quite well w/ LF mw potentiometric data

POTENTIOMETRIC SURFACE MAP
WATAUGA COUNTY LANDFILL
WATAUGA COUNTY, NORTH CAROLINA

Job No.: 6520-20
Scale: NOT TO SCALE
Date: 09 SEPTEMBER 95

FIGURE 4

Draper Aden Associates
CONSULTING ENGINEERS
Blacksburg, VA – Richmond, VA – Nashville, TN

2.4.1.2 Fracture Trace Lineaments

The application of predictive contaminant transport models in fracture rock systems is hampered by the overwhelming difficulties encountered in fracture system characterization. Data collection is essential and lays the foundation for modeling the behavior of a site. Before modeling the fracture system and before being able to make even simple assumptions regarding site specific fracture flow rates immediately surrounding individual well heads, several important characteristics must first be described.(EPA/540/4-89/004. August 1989).

Realizing an accurate and comprehensive fracture system characterization is essential before effective modeling of the fracture system, the initial objective of the fracture study was to document all available information regarding the mineral lineation, layering, and foliation trends within the host bedrock. Attempts were then made to relate the trends and orientations of mineral lineation, layering, and foliation to the nature of the discontinuities within the host bedrock.

Layering within the mixed rocks has been produced by shearing of the migmatitic layering found in the underlying Cranberry Gneiss. The most strikingly layered rocks are the most sheared and less sheared rocks are generally more granitic and have a migmatitic aspect (Bryant and Reed, 1970) The mixed rocks appear to be a gradation zone between migmatitic Cranberry Gneiss and the overlying schist, gneiss, and amphibolite and as such reflect characteristics of both.

Lineation within the host bedrock is predominately formed by alignment of minerals and mineral aggregates and by elongated porphyclasts and boundings. This lineation was formed during synkinematic recrystallization (Bryant and Reed, 1970). Lineation generally trends northwest although the gradational character of the contact zone represented by the "mixed rocks" has resulted in a slightly variable or wavy lineation trend.

Foliation, marked by aligned micas, tabular quartz-feldspar laminae, and planar arrangement of amphiboles, is well developed in most of the rocks of the Blue Ridge Thrust sheet. In the Cranberry Gneiss, foliation is cataplastic and is formed primarily by planar orientation of micaceous minerals. In most of the technically overlying mica schist, gneiss, and amphibolite, cataclastic effects are lacking, and foliation apparently formed during synclinematic recrystallization. (Bryant and Reed, 1970) Foliation generally trends northwest similar to lineation.

Cracks, fissures, fractures, joints, and shear zones within the regional bedrock interconnect to form the fracture system. The global geometry of the fracture system appears to possess both continuous and discontinuous zones. The continuous fracture zones primarily consist of conductive fractures that are very long compared to the region under study. The discontinuous fracture zones consist of dead end fractures, isolated fractures, and less conductive fracture zones.

The flow rates within specific discontinuities at site specific locations can be expected to depend on a variety of factors including the degree of interconnectedness, the frequency within single planes, the density per unit volume of rock, the effective aperture, and orientation and location in relation to gradient and relation to other discontinuities. Preliminary fracture analysis indicates that general approximations of these factors may be related to metamorphic grade contrasts and to general physiographic expressions, in and surrounding the site. Preferential groundwater flow regimes interpreted within the bedrock are expressed at the surface by the evolution of topographic drainage features and springs .

Recent site reconnaissance and outcrop study documented the occurrence, nature, and orientations of fracture trace lineaments in local gneiss and schist bedrock assemblages.

The revised Vicinity Geology Map depicts both the micro-textural and macro-textural linear features identified at the site. The micro-textural linear features observed at seven (7) site bedrock exposure locations are represented by strike and dip symbols. The macro-textural linear features of nine (9) site physiographic features are represented by trend symbols.

Two (2) primary lineament sets were observed at both the microtextural and macrotextural scale. The major lineament set is oriented parallel with layering, lineation, and foliation trends at approximately N55°W. Layering and foliation lineaments dip approximately 45° NE. A minor lineament set is oriented parallel with fracture and joint trends at approximately N10°E and dips almost vertically at 80° to 85°SE.

Site physiographic features (microtextural) are directly related to the trends and orientation of mineral layering (macrotextural) within the site bedrock. Layering within the "mixed rocks" (pm) was produced by shearing of the migmatitic layering found in the underlying Cranberry Gneiss (pc). The mixed rocks appear to be a gradation zone between migmatitic Cranberry Gneiss and the overlying schist, gneiss, and amphibolite and as such reflect characteristics of both. The most strikingly layered rocks are the most sheared. Conversely, less sheared rocks are generally more granitic and have a migmatitic aspect (Bryant and Reed, 1970).

Northwest oriented site drainages developed over the most strikingly layered and sheared, schistose zones of the "mixed rocks". Northwest oriented site ridges developed over the more granitic zones of the "mixed rocks".

Layering and foliation in the metamorphic gneiss and schist bedrock assemblages occurring in the vicinity of the site are oriented parallel to, and dip away from the Grandfather Mountain window, located to the southwest. The gross structure of the Blue Ridge thrust sheet in the Grandfather Mountain area is that of an irregular dome with foliation and layering dipping away from the Grandfather Mountain window. The Linville Falls Fault separates the site bedrock assemblages of the Blue Ridge thrust sheet from the

Grandfather Mountain Window. Foliation and layering in bedrock near the window are generally subparallel to the Linville Falls Fault (Bryant and Reed, 1970). This alignment results in the general N55°W orientation and approximate 45°NE dip of the major lineament set in the vicinity of the site.

The northwest drainage below the Bolick site follows a path that combines both of the two (2) primary lineament sets observed at the site. Upper reaches of the northwest drainage trend parallel to mineral layering, lineation, and foliation in the host bedrock as well as parallel to the general northwest trending contact between the amphibolite/hornblende gneiss-mica schist and gneiss and the "mixed rocks" assemblage (N55°W). Upon reaching an area where the amphibolite/hornblende gneiss is not stratigraphically overlain by the mica schist and gneiss, (inferred from drilling of MW-18 as well as the distribution of residual soil distributions depicted on the Watauga County Soil Survey), the drainage trends N10°E, parallel to bedrock fracture and joint lineations.

The north trending portion of the northwest drainage below the landfill Bolick site, the northern landfill drainage-Rocky Branch tributary, and the Rocky Mountain Heights-Mutton Creek tributary are all oriented approximately N10°E. The north trends of these three drainages are in contrast to the major northwest trends existing across the site described previously. Recent site reconnaissance observed microtextural expression of the north tending lineament in fractures or joints at two (2) locations (denoted #4 and #6 on Figure 3).

The north trending fracture trace lineaments may be a result of joint-stress fracturing related to the thrust faulting. Bryant and Reed note that the majority of the discontinuities in the bedrock likely owe their origin to stresses related to thrust faulting. They suggest that all or part of the "mixed rocks", existing between the Cranberry Gneiss and the tectonically overlying amphibolite and hornblende gneiss, may be tectonic slices along a fault zone. Bryant and Reed are careful to note that local evidence of a major fault may be inconclusive particularly where digitations of amphibolite, "mixed rocks", and mica schist and gneiss project well into the Cranberry Gneiss.

2.4.2 Site Hydrogeology

During the Bolick site investigation, a variety of aquifer tests were performed on the network of monitoring wells and piezometers at the Watauga County Landfill property. The information derived from the aquifer tests is presented in Section 3.1.8 of the Assessment Plan. Estimates of variable flow rates within the interconnected aquifer system beneath the site were utilized to define a preliminary model of the fracture aquifer system's global geometry.

2.4.2.1 Aquifer Media

Aquifer media encountered during the drilling of the assessment monitoring well network are classified into four (4) primary categories. These four (4) primary aquifer mediums are generally characterized by location, texture, and geology as follows.

Unconfined, surficial soil aquifer: residing in saprolitic silty sands and sandy silts at lower elevations, generally ranging approximately ten (10) to thirty (30) feet in depth, hydraulic conductivity variable although capable of flow rates up to 10 ft/day in developed preferential flow paths.

Unconfined, micaceous schist and gneiss bedrock aquifer: residing in a relatively porous, weathered micaceous schist and gneiss, situated above competent amphibolite/hornblende gneiss, located in the topographic low of the Rocky Branch watershed, approximate thickness likely ranges up to one hundred feet (70 feet documented in MW-15), highly transmissive.

Semi-confined, amphibolite/hornblende gneiss bedrock aquifer: residing in competent, dense gneiss, characterized by small aperture, low density, infrequent fractures, located in the north-northeast portion of the site in the Rocky Branch watershed, fracture occurrence likely diminishes with depth, moderately transmissive.

Semi-confined, layered schist and gneiss bedrock aquifer: residing in a layered schist and gneiss characterized by textural contrasts, located in the central and south-southwest portion of the site, fracture occurrence likely diminishes with depth, variable transmissivities.

2.4.2.2 Potentiometric Surface

well installation readings only.

Examination of static water levels in site monitoring wells, business and domestic potable wells, piezometers, and running streams reveal that all four (4) aquifer media produce a similar potentiometric surface. The similar potentiometric surface suggests the various aquifer media are interconnected by hydraulically conductive fractures. The potentiometric surface of the four (4) aquifer media in the vicinity of the site is presented in Figure 4.

Groundwater elevations in the five (5) nested well sites are higher for the deeper well relative to it's shallow nested pair, indicating groundwater from the deeper bedrock fracture aquifer system discharges to the shallow soil aquifer at lower elevations. Downward vertical flow direction was observed at the contact between the micaceous schist and gneiss and the underlying amphibolite/hornblende gneiss. Static water level elevations collected for all site monitoring wells and piezometers during the background assessment monitoring events are listed in Tables 4A and 4B.

this data correlates quite well w/ MW potentiometric data

2.4.2.3 Recharge Sources

The upgradient recharge areas for the site aquifer media are comprised of Rocky Knob (approximate elevation 4000 ft.) to the east of the site and a smaller knob (approximate elevation 3500 ft.) to the southwest. Rocky Knob is the primary recharge source in the vicinity of the site. The Rocky Branch watershed is additionally recharged from the northeast by a northwest trending ridge (approximate elevation 3500 ft.). The approximate elevations of potentiometric surface of the aquifer media in the vicinity of the site range from 3100 ft. to 3305 ft.

Along the base of Rocky Knob, discharge is expressed at the surface by the presence of springs along a northwest trending contact between the amphibolite/hornblende gneiss bedrock and the zone of "mixed rock" (Figure 3). A series of previously documented springs subsequently covered by landfill activities also follow this trend to the northwest.

MW-9 located near saddle has highest H_2O table reading indicating potentiometric divide location

Recharge to the springs at the base of Rocky Knob and recharge to the Rocky Mountain Heights subdivision is provided by the substantial upgradient area of Rocky Knob. The primary westward groundwater flow direction from Rocky Knob, and a subjugate topographic and hydraulic divide south of the landfill (Figure 4), likely inhibit flow from the north across the ridge separating the landfill from the Rocky Mountain Heights subdivision.

Per recommendations by the NCDEHNR, additional investigations have included sampling of the spring located at the base of Rocky Knob adjacent to the landfill . The spring is located at the head of the drainage adjacent to the Carroll residence well (well reference no. 12) (Figure 2). The Carroll residence well is the only potable well in the Rocky Mountain Heights Subdivision identified as significantly impacted by volatile organic compounds. The analyses of the spring resulted in no organic compounds detected.

The previously documented springs located beneath the landfill may be jointly recharged by both Rocky Knob and by the knob located to the southwest of the site. A spring capture outfall system was installed prior to waste disposal to pipe out the spring groundwater from beneath the waste. The spring capture outfall system (S-2), is currently sampled semiannually as part of the assessment surface water sampling program.

The potentiometric surface inferred between MW-6 and MW-9 could possibly be influenced by the spring capture outfall which may have failed, resulting in the doming of groundwater within the fill. An overhead power line traverses the upgradient, southern limits of the waste disposal area. An unexcavated area remains within the disposal area to support the transmission lines. Draper Aden Associates proposes to install a piezometer or monitoring well in the unexcavated area near the power line to provide addition potentiometric data and/or groundwater quality data between MW-6 and MW-9 to investigate potential mounding.

The paucity of leachate seeps year-round suggests that groundwater residing within the fill migrates into the underlying soil and bedrock aquifer(s) rather than direct discharge to the surface. Further study into leachate generation will involve discussions of historical leachate production with various landfill operators, as well as current site assessments. Leachate investigations will focus on determining the source, transport, and fate of water currently residing in the fill.

2.4.2.4 Aquifer Testing

A variety of aquifer tests were performed on the assessment monitoring wells to evaluate relative flow rates of each respective accessed aquifer medium. The approach applied to selecting appropriate aquifer test methods for various aquifer media is presented in the following section. The information derived from the aquifer testing is utilized to define the rate of groundwater flow within various fracture and soil aquifer media potentially impacted by landfill waste disposal activities. Aquifer test results support the flow regimes as presented previously on site hydrogeology.

A summary of aquifer test results is presented in the following Table A1. Aquifer test method calculations can be found in Appendix IV of the Activity Report. A presentation of similar aquifer testing, performed on all previously installed monitoring wells and piezometers at the Watauga County Landfill, can be found in Section 3.1.8.1 of the Assessment Plan. A summary of aquifer test results from the previous aquifer testing is also presented in Table A2.

Both slug (bail) tests and single-well recovery pump tests were performed initially. Test data and results were evaluated to determine the most appropriate method to utilize within specific aquifer mediums accessed by individual wells. After initial aquifer testing attempts, single-well recovery pump test methods were refined by tailoring pumping rates and durations to each individual well recovery rate. Slug test methods were refined by emphasizing either early or late data collection efforts. Test method refinements attempted to produce data that was more representative of individual aquifer media for method type-curve and straight line matching.

The Bouwer and Rice slug test method (Bouwer, 1989), applicable to unconfined systems, was utilized to calculate the hydraulic conductivity (K) from slug test data obtained from wells accessing the soil aquifer. The Cooper-Bredehoeft-Papadopulos slug test method (Cooper, et al, 1967), applicable here for confined systems, was utilized to calculate the transmissivity (T) and storage coefficient (S) from slug test data obtained from wells accessing the bedrock fracture system aquifer. The Theis recovery method (Theis, 1935) was utilized to calculate the transmissivity (T) and storage coefficient (S) from recovery pump test data obtained from all wells capable of sustaining sufficient pumping rates and purge durations. For the purpose of obtaining a comparative data set, transmissivity results were transformed to hydraulic conductivity (K) by dividing the transmissivity (T) by the well screen length. Aquifer thickness was taken to be the well screen length in hydraulic conductivity calculations under the assumption that the fracture bedrock production zone trapped by the well was unique, and provided all the recharge to the well.

Evaluation of initial aquifer test results indicate that the single-well recovery pump test method was most robust for application to moderate and fast recovering wells, and slug test methods were the most applicable to slow recovering wells. Table A1 provides the pump aquifer test results most representative of aquifer conditions, as chosen from the variety of tests performed. As previously noted, aquifer test results were chosen based on the ability of the test method to produce reliable method type-curve and straight line matching data.

The results from the conventional well-flow equations utilized for representing fracture flow rates (i.e. Cooper, Bredehoeft, Papadopulos slug test method and Theis recovery method) were developed for homogenous and isotropic aquifers and therefore may not describe fracture flow adequately. True fracture flow test methods will require prolonged (>2 days) pumping of a well and the existence and monitoring of several nearby nested well sets that also access the same fracture system. Prolonged, nested well pump tests may prove to be beneficial and cost effective after more information is attained during the assessment. The confined flow test methods were utilized primarily for comparison purposes and as such display the range of relative transmissivities existing within the various fracture systems.

2.4.2.5 Aquifer Test Results

2.4.2.5.1 *Soil Aquifer Medium*

Both the Bouwer and Rice slug test method and the Theis recovery method were analyzed to obtain hydraulic conductivity or transmissivity results from the three (3) assessment monitoring wells installed in the unconfined soil aquifer medium (i.e. MW-11, MW-13, and MW-16).

Well MW-13 exhibited slow recovery rates and was not capable of sustaining sufficient pumping rates and purge durations for obtaining proper, comparative recovery test data. Conversely, the recently installed soil aquifer well, MW-11, recovered too fast to provide useful slug test data with the field methods utilized. The Theis recovery method was chosen to calculate the transmissivity (T) from recovery data from both this fast recovering well, MW-11, and the moderately fast recovering well, MW-16.

The test results from the two methods utilized for the moderately fast recovering well MW-16 exhibit the robust nature of the Theis recovery method when compared with the Bouwer and Rice slug test method. The calculated hydraulic conductivity from the Theis recovery method result was twice as fast (11.827 ft/day) than the Bouwer and Rice slug test method result (5.131 ft/day). The discrepancy between recovery pump test and slug test results increases with faster recovering wells. The increased accuracy and appropriateness of the recovery pump test method becomes apparent when necessary early-time slug test data is completely missed in the fast recovering wells and the comparative slug test result exhibit, in error, a relative decline in hydraulic conductivity.

not V

As indicated in the final aquifer test result summary (Table __), the calculated K — hydraulic conductivity for the slower recovering soil aquifer well (MW-13) was approximately 0.445 ft/day, compared with 6.520 ft/day (MW-11) and 15.096 ft/day (MW-16) for the faster recovering soil aquifer wells.

2.4.2.5.2 *Amphibolite/Hornblende Gneiss Aquifer Medium*

Both the Cooper-Bredehoeft-Papadopulus (C-B-P) slug test method and the Theis recovery method were utilized in initial attempts to calculate comparable transmissivity (T) from slug and pump test recovery data obtained from the four (4) assessment monitoring wells recently installed in the fractured amphibolite/hornblende gneiss aquifer medium (i.e. MW-10, MW-15, MW-17 and MW-18).

MW-10 exhibited slow recovery rates and was not capable of sustaining sufficient pumping rates and purge durations for obtaining proper, comparative recovery test data. Wells MW-15 and MW-17 exhibited slow to moderate recovery rates. Although the slug and recovery test method results compared favorably for MW-15 and MW-17, Theis single-well recovery pump test method results are presented in Table 2. It is generally recognized that the greater impact on the aquifer resulting from recovery pump test purge volumes produces more useful and accurate data for estimation pump of flow characteristics. Similarly, the Theis recovery method provided the most accurate and applicable data for the only well installed within the amphibolite/hornblende gneiss aquifer medium to exhibit fast recovery rates, MW-18.

As indicated in the final aquifer test result summary (Table 1A), calculated hydraulic conductivity for the slower recovering amphibolite/hornblende gneiss aquifer well (MW-10) was approximately 0.0027 ft/day, compared with 0.154 ft/day (MW-15) and 0.116 ft/day (MW-17) for thc slow to moderate, and 15.888 ft/day (MW-18) for the fast recovering amphibolite/hornblende gneiss aquifer well.

TABLE A1
WATAUGA COUNTY LANDFILL ASSESSMENT
AQUIFER FLOW TESTING RESULTS SUMMARY

Monitoring Well	Filter Pack * Depth Interval (ft)	Aquifer Medium	Bouwer-Rice Slug Test	Cooper, Bredehoeft, Papadopulus Slug Test	Theis Recovery Test	
MW-8	63.0 - 51.0	Layered Schist/Gneiss			$T = 10.531$ ft^2/day $K = 0.877$ ft/day	p€m
MW-9	84.0 - 72.0	Layered Schist/Gneiss			$T = 2.379$ ft^2/day $K = 0.198$ ft/day	p€m
MW-10	63.0 - 56.0	Amphibolite/ Hornblende Gneiss		$T = 0.0322$ ft^2/day $K = 0.00268$ ft/day		p€a
MW-11	23.0 - 11.0	Soil			$T = 78.235$ ft^2/day $K = 6.520$ ft/day	p€m
MW-12	70.0 - 58.0	Layered Schist/Gneiss			$T = 173.232$ ft^2/day $K = 14.436$ ft/day	p€m
MW-13	29.0 - 17.0	Soil	$K = 1.57E-04$ cm/sec $= 0.445$ ft/day			p€a
MW-14	69.0 - 57.0	Micaceous Schist/Gneiss			$T = 141.926$ ft^2/day $K = 11.827$ ft/day	p€m
MW-15	176.0 - 163.0	Amphibolite/ Hornblende Gneiss			$T = 2.007$ ft^2/day $K = 0.154$ ft/day	p€m
MW-16	24.0 - 12.0	Soil			$T = 181.152$ ft^2/day $K = 15.096$ ft/day	p€a
MW-17	93.0 - 81.0	Amphibolite/ Hornblende/Gneiss			$T = 1.395$ ft^2/day $K = 0.116$ ft/day	p€m
MW-18	70.0 - 58.0	Amphibolite/ Hornblende Gneiss			$T = 190.656$ ft^2/day $K = 15.888$ ft/day	p€a

T = Transmissivity; K = Hydraulic Conductivity

* as recorded from ground elevation

2.4.2.6 Nested Well Test Observations

The following three (3) sets of recently installed nested wells were observed during aquifer testing to determine the interconnectedness of the aquifer(s) at variable depths:

- MW-11 and MW-12
- MW-13 and MW-18
- MW-14 and MW-15

During purging of the deep well for each nested set, the water level in the adjacent shallow well was observed. Loss of groundwater elevation in the shallow well to the deeper portion of the aquifer being pumped via the deeper well, would indicate hydraulic communication in the aquifer.

Recovery rates found in the shallow nested wells MW-11 and MW-14, were much too fast to be impacted by the relatively short duration pumping (1½ hour) of the deeper nested well. Even the deep nested wells were capable of constant flow rates approaching 7 gallons per minute. Therefore, the inference provided by this observation is inconclusive and provides little actual indication as to the degree of interconnectedness at these aquifer depths.

Although the recovery rate found in the shallow nested well, MW-13, was relatively slow, the recovery rate of the deeper nested well, MW-18, was still too difficult to significantly overcome with the relatively short duration pumping (½ hour) of the recovery test. Nonetheless, a connection between the soil and bedrock aquifer was observed at the location of this nested well set. After pumping the bedrock aquifer at 3 gallons per minute for 18 minutes, the water level in the soil aquifer dropped 0.07 feet.

As indicated in the description of hydrogeologic conditions presented in section 2.6 of the Assessment Plan, the shared potentiometric surface of the various aquifer media suggest that these aquifer zones are interconnected by hydraulically conductive fractures, joints, and/or shear zones. Comparison of the individual potentiometric surfaces of the nested wells and piezometers indicate that groundwater from the fracture system is discharged to the soil aquifer at lower elevations. Groundwater discharge to the soil aquifer and surface eventually migrates to the South Fork of the New River and its tributaries.

Comparison of the individual potentiometric surfaces within the micaceous schist/gneiss (MW-14) and the amphibolite/hornblende gneiss (MW-15), located adjacent to Rocky Branch, indicate a downward vertical flow direction exists at the contact between these two different metamorphic grade formations.

2.4.2.7 Aquifer Flow Summary

The recent aquifer flow testing results generally support the conclusions contained in the aquifer flow characterization presented in Section 3.1.8.1 of the Assessment Plan. The increased size of the area characterized revealed additional observations. Conservative estimates of the groundwater rates of the mobile groundwater at the site continue to range from 0.01 ft/day to 10 ft/day. These findings generally agree with research provided by Zurawski (1978) that indicate hydraulic conductivity of the fractured metamorphic aquifer domain potentially range between 1 and 100 ft/day.

Additional observations of flow characteristics obtained from recent drilling and aquifer testing are summarized below.

1. Fast flow rates, comparable and even faster than flow rates observed within preferential soil flow paths, occur also within portions of the fracture system.

2. The nature and flow characteristics of the various bedrock fracture media can vary considerably depending on both metamorphic assemblage contrasts and physiographic location.

    a. The micaceous schist/gneiss aquifer medium is a relatively porous and permeable medium that supports relatively fast flow rates.

    b. The amphibolite/hornblende gneiss aquifer medium tends to be predominantly characterized by tight aperture, infrequent fractures that support relatively moderate flow rates. Fracture aperture widths, densities, and frequencies within this medium can be expected to vary considerably depending on physiographic location.

    c. The layered schist/gneiss aquifer flow rates are influenced by a variety of textural bedrock features (layering, shear zones, foliation, etc.) and appear related to physiographic location. Physiographic expressions within the layered schist/gneiss are influenced by textural contrasts related to the variable metamorphic assemblages comprising this mixed unit.

III. INITIAL ASSESSMENT FIELD ACTIVITIES

3.1 Landfill Cover Depth Verification

The initial evaluation of existing cover conditions compiled for the Assessment Plan report was conducted by discussing site operations with landfill personnel and visually inspecting the cover with the landfill supervisor. The preliminary cover characterization indicated that approximately two to four feet of cover were applied and graded on the landfill. Active fill areas were reportedly covered daily by six inches of soil. Further, the operational face of the landfill was kept to a minimum by the use and effective placement of compacted bales of waste.

Draper Aden Associates performed cover depth verification tests on the closed out areas of the Watauga County Landfill on October 20, 1993. Soil probes were taken at random points to verify the total depths of cover material. A landfill grid diagram (Figure 2, Activity Report) shows where soil probes were taken. The overall cover depth at each point was 2 feet or greater, although an occasional piece of debris was partly exposed.

An additional 1 foot cap subbase grade was installed over the waste disposal area. Installation of the interim cap followed. Final cap specifications were deferred pending the results of groundwater/surface water infiltration studies conducted on the waste disposal area.

3.2 Landfill Gas Screening

The landfill gas screening program was conducted by Draper Aden Associates concurrent with the landfill cover depth verification. The landfill grid diagram (Figure 2, Activity Report) was utilized in determining appropriate gas sampling locations. All areas were initially identified on the site plan, and gridded off on 100 foot centers. Based on the initial gas sampling plan, there were 114 grid nodes for sampling. However, upon arrival at the site, and discussions with landfill operation, it was recognized that it would not be feasible to sample active fill areas of the landfill. As a result, 31 grid node points were eliminated from the survey leaving a total of 83 sampling points. Using compass bearings, and recognizable physical features of the site, the grid was laid out across the existing fill area. This included both the sanitary fill and demolition fill areas.

The initial gas screening program was begun using a Geotechnical Instruments Limited infra-red gas analyzer. This instrument is designed to obtain accurate data on the concentrations of the main constituents of landfill gas; methane, carbon dioxide, and oxygen. It includes an internal sampling pump which draws gas samples through an attached sampling hose. The instrument is accurate to ± ½ of a percent by volume methane, ½ of a percent by volume carbon dioxide, and 1% by volume oxygen. The relative accuracy decreases by a factor of 2 as the upper explosive limit is reached.

The results of the initial gas screening indicated no methane production at the approximately 83 sampling points. In addition, no carbon dioxide production was measured. Oxygen by percent volume in the atmosphere varied approximately three tenths of 1%. At no time did oxygen percent by volume decrease to a level below 20.8 percent. The conclusions drawn from this initial gas survey are that methane or other volatile gas production does not appear to represent a significant human hazard at or near the landfill at this time.

3.3 Assessment Groundwater Monitoring Well Installation

Fourteen (14) additional assessment monitoring wells were installed at the site as proposed in the Assessment Plan for the delineation of the horizontal and vertical extent of the contaminant occurrence(s). Locations of all the assessment monitoring wells are presented on the Vicinity Map (Figure 1), Groundwater Monitoring Program Map (3), and on the Groundwater Potentiometric Map (Figure 4).

Three (3) of the proposed additional assessment wells, MW-5, MW-6, and MW-7, were installed in August, 1992, along the topographic divide between the Bolick site and the landfill waste disposal area (originally designated PZ-19, PZ-24, and PZ-25).

Eleven (11) of the additional assessment wells, MW-8 through MW-18, were installed in January and February, 1994, after approval by the NCDEHNR Solid Waste Section. Three (3) of these additional assessment wells are located adjacent to the waste disposal area, six (6) are located beyond the landfill property boundary, and two (2) are located along the landfill property boundary.

3.3.1 Assessment Monitoring Well Location Revisions

The relocation of five (5) of the proposed additional assessment monitoring wells (MW-12, MW-13, MW-14, MW-15, and MW-18) was necessary due to the proposed rerouting of U.S. Highway 421, which is scheduled for construction over the next several years. The construction right-of-way for the proposed route 421 bypass would have directly impacted the original locations for these five (5) proposed assessment monitoring wells likely requiring their premature abandonment.

The approximate location of the section of the proposed U.S. Highway 421 bypass and construction right-of-way that would have impacted the original proposed assessment monitoring well locations is presented in Figure 1. The Site Map depicts the assessment monitoring well locations, as revised for the highway.

Location Revisions along Rocky Branch

Revised assessment monitoring well locations along Rocky Branch include MW-14 and MW-15.

The revised location for both MW-14 and MW-15 is northwest of the crossing of the proposed U.S. Highway 421 bypass across the landfill tributary of Rocky Branch and south of Rocky Branch. These two (2) wells are screened within the fracture aquifer system. The revised locations maintain the intent of the original proposed locations by providing two (2) additional fracture aquifer assessment wells, to delineate both the horizontal and vertical extent of the contaminants within the bedrock fracture aquifer system, previously identified at MW-2.

The screen interval of MW-14 is placed at a depth that coincides with the base of a weathered mica schist aquifer found at this location. Substantial water production was encountered during drilling within this bedrock zone. MW-15 is screened within a fracture system that coincides with the fracture zone assessed by MW-2. Both wells are screened to access a fracture system within a competent amphibolite/hornblende gneiss occurring at approximately 170 feet to 172 feet in depth. Monitoring of domestic wells accessing the fracture system below this location do not suggest that the contaminants have migrated a substantial distance beyond the revised well locations.

Location Revisions below the Bolick Site (northwest drainage)

Revised assessment monitoring well locations below the Bolick site, along the northwest drainage, include MW-12, MW-13, and MW-18.

The revised location for MW-12 involved moving the original proposed location south of the proposed U.S. Highway 421 bypass. The revised locations for MW-13 and MW-18 involved moving the original proposed locations north of the proposed U.S. Highway 421 reroute. The revised locations for MW-13 and MW-18 are immediately south of the Hollar and Green Produce access road, as well as adjacent and west of the tributary draining the Bolick site.

The revised locations maintain the intent of the original proposed locations by providing two (2) monitoring wells, MW-11 and MW-13, to delineate the horizontal extent of the contaminants within the soil aquifer below the Bolick site and two (2) monitoring wells, MW-12 and MW-18, to delineate the horizontal extent of the contaminants within the fracture system below the Bolick site. Contaminants have previously been detected within the soil aquifer below the Bolick site at MW-3. Contaminants have previously been detected within the fracture aquifer system below the Bolick site at the Nissan-Mazda dealership's production well.

Two (2) previous potable well sampling events identified the Boone Nissan-Mazda dealership's production well (well reference no. 4) to be impacted by Volatile Organic Compounds (VOCs) (presented in Appendix II). The locations of MW-12 and MW-18 are designed to access the core fracture system zone below the Bolick site and the Nissan-Mazda dealership's production well as determined by fracture trace analysis. MW-12 and MW-18 are located a sufficient distance apart to account for potential fast flow rates that may be transporting contaminants along this preferential flow path.

The Nissan-Mazda dealership's production well is 204 feet in depth and encountered significant water production zones at 70 feet (20 gpm) and again at 175 feet (25 gpm) as indicated by the driller's well record. MW-12 and MW-18 are screened at a depth that coincides with the first substantial water production zone encountered within competent bedrock. This allows the assessment monitoring well screen to be located in the aquifer domain closest to the known contaminant domain.

The Nissan-Mazda dealership's septic drainfield is located on the hillside immediately north of the Nissan-Mazda dealership's production well, as indicated on Figure 1. Three (3) monitoring wells exist below the Bolick site that were installed by the dealership for the purpose of monitoring the portion of the soil aquifer potentially impacted by the dealership's septic drain fields. The location of the septic system suggests that septic effluent may be potentially impacting the potable well system. Liquid samples were obtained on April 29, 1993 from the Nissan-Mazda Dealership's septic system to investigate potential impacts on the Nissan-Mazda Dealership's potable well system. Sampling was performed by the Appalachian District Health Department and the NCDEHNR Solid Waste Section. Sample analysis was performed by the N.C. State Laboratory of Public Health.

Twenty-two (22) organic compounds were detected in septic effluent obtained from the Nissan-Mazda Dealership's septic system, comprised of chlorinated hydrocarbons, phenols, toluene, xylenes, benzene and substituted benzenes, napthelene and substituted napthelenes, phthalates, acetone and other related hydrocarbon compounds. The occurrence of many of the compounds detected in the Nissan-Mazda Dealership's potable well can be attributed to either the compound's occurrence in the septic waste stream and/or transformation products of these septic waste stream compounds. The integrity of the well heads for additional landfill assessment wells, MW-11, MW-12, MW-13 and MW-18, may also be significantly compromised by the influence of potential drainfield contaminants.

beneath the landfill. Further steps are being taken to investigate the source of these trace level detections of contaminants. Current and future residential well sampling results will be utilized to further assess contaminant source and migration within the subdivision.

Another additional assessment monitoring well located adjacent to the waste disposal area is monitoring well MW-10. MW-10 is located immediately downgradient of the fill area (as indicated in Figure 4). The two wells, MW-2 and MW-4, of the original groundwater monitoring network, monitor the groundwater flow path in this NE drainage, but are located approximately 400 feet away from the waste disposal area. MW-10 will provide groundwater quality data that will allow for further evaluation into source, transportation and migration rates, and fates of previously identified contaminants. Monitoring well MW-10 is screened at the first hydraulically conductive bedrock fracture zone encountered during drilling at approximately 59 feet in depth.

Locations along the Landfill Property Boundary

Two (2) additional assessment wells are located at the facility property boundary. Monitoring well MW-17 is located below the Bolick site and monitoring well MW-16 is located along the tributary of Rocky Branch.

Assessment monitoring well MW-17 is screened within the first significant water production zone encountered during drilling within the bedrock at approximately 88 feet in depth. The existing well monitoring the preferential flow path at this location, MW-3, is screened within the soil interval.

Assessment monitoring well MW-16, located at the facility property boundary along the tributary of Rocky Branch, is screened within the surficial soil aquifer. MW-4 of the current Watauga County Landfill Groundwater Monitoring Well Network is located at the facility property boundary, within the soil aquifer, along the Rocky Creek tributary. The intent of the additional soil aquifer assessment well was to further delineate the horizontal extent of the preliminarily identified contaminants within the soil aquifer identified at MW-4. As discussed in the following Section IV., the background assessment sampling and analysis of both MW-4 and MW-16 has resulted in the detection of no target organic parameters.

3.4 TCLP Analysis and Handling of Drill Cuttings

The drill cuttings from the eleven assessment wells installed at the Watauga County Landfill were contained and collected on plastic during drilling. The drill cuttings were then moved to a concrete pad located next to the landfill maintenance facility, utilizing both 55 gallon drums and a landfill loader bucket, and placed under plastic. Locations of individual monitoring well drill cuttings were maintained on the concrete pad in order to allow identification, sampling, and handling of individual stockpiles.

Toxicity characterization testing, utilizing the SW-846 Method 1311 Toxicity Characteristic Leachate Procedure (TCLP), was performed on a sample from the drill cutting stockpile identified as the most likely to contain elevated levels of contaminants. The TCLP testing indicates the drill cuttings sample to be nonhazardous. The TCLP analytical results indicate contaminant levels below method detection limits for most analytes and far below Federal regulatory levels established for hazardous waste for the four (4) detected analytes.

Sampling and toxicity characterization testing was conducted on the drill cutting stockpile from monitoring well MW-8. Previous contaminant characterizations, as well as air monitoring results obtained during drilling indicated the drill cuttings from MW-8 as the most likely to contain elevated levels of contaminants.

The TCLP analysis of the drill cuttings sample only detected one metal and three (3) volatile organic compounds above method detection limits. Barium was detected at 1.8 mg/l. This level is far below the Federal regulatory level for hazardous waste (40 CFR 261 established limit) of 100 mg/l. Chloroform, 1,1-Dichloroethylene, and Trichloroethylene were detected at 0.038 mg/l, 0.033 mg/l, and 0.025 mg/l, respectively. Again, these volatile organic compound levels are far below the federal regulatory levels for hazardous waste of 6.0 mg/l, 0.7 mg/l, and 0.5 mg/l, respectively. No other compounds were detected.

Draper Aden Associates requested, on behalf of Watauga County, approval from the NCDEHNR Solid Waste Section for the handling of drill cuttings from the eleven assessment monitoring wells installed at the Watauga County Landfill. The low levels of the four (4) compounds detected in the TCLP analysis of the drill cuttings sample do not warrant special disposal considerations. The NCDEHNR Solid Waste Section approved incorporating the drill cuttings in the closure cap subbase grade for the waste disposal areas of the Watauga County Landfill.

3.5 Health and Safety Monitoring Program

An extensive health and safety program was conducted concurrent with all initial assessment field activities to assure that safe working conditions are maintained at the site. Appendix II of the Assessment Plan, the Health and Safety Plan (HASP), details the health and safety measures established to mitigate potential site physical and chemical hazards. The health and safety program incorporates site control, decontamination procedures, personal protective equipment, air monitoring activities, and other associated measures to protect assessment workers on site.

Air Monitoring

Air monitoring conducted during invasive drilling activities incorporated continuous real-time air monitoring utilizing a Photo Ionization Detector (PID) and Lower Explosive Limit (LEL) meter as well as the collection of gas/vapor Draeger detector tubes, personal charcoal filter tube air samples, and well bore ambient air samples.

The results obtained from the continuous real time air monitoring were utilized to guide initial personal protective equipment applications. PID and LEL readings were compared with the exposure criteria for all suspected contaminants established by the Occupational Safety and Health Administration (OSHA) and the National Institute for Occupational Safety and Health (NIOSH). Exposure criteria levels for all suspected contaminants is listed in Attachment B of the Health and Safety Plan. When the real-time air monitoring indicated exposure levels exceeding the exposure criteria, personal protective equipment was upgraded appropriately as outlined in the Health and Safety Plan.

All of the combined gas/vapor Draeger detector tube, personal charcoal filter tube, and ambient air sampling and analyses collected during the recent assessment drilling project resulted in the nondetection of all suspected analytes. Personal charcoal filter tube and ambient air sampling and analyses results as well as real-time air monitoring and draeger tube analyses field notes can be found in Appendix III of the Activity Report.

Gas/vapor Draeger Detector Tube Analysis

Gas/vapor Draeger detector tubes were collected during invasive drilling activities when the PID indicated potentially elevated gas/vapor levels. The four (4) gas/vapor analyte Draeger detector tubes utilized for the corroborative air sampling program are listed below.

Carbon Tetrachloride (CCl_4)
Chloroform ($CHCl_3$)
Benzene
Vinyl Chloride

The analytes for these four (4) gas/vapor Draeger detector tubes have relatively low established exposure criteria. The PID spike, observed during the drilling of MW-8 when the groundwater interface was reached, indicated the potential exceedance of the exposure criteria of these four (4) compounds. As indicated in the HASP air monitoring field notes, all of the gas/vapor Draeger tube testing resulted in the nondetection of these four (4) suspected volatile organic compounds.

Personal Charcoal Filter Tube Analysis

Personal charcoal filter tube air samples were collected during the drilling of each assessment monitoring well and analyzed for the eight (8) suspected volatile organic compounds with lower established exposure criteria. A PID spike, observed during the drilling of MW-8 when the groundwater interface was reached, indicated the potential exceedance of the exposure criteria for these eight (8) compounds. The eight (8) volatile organic compound analytes and respective test methods utilized to analyze the personal charcoal tube filter samples are listed below.

Carbon Tetrachloride (CCl_4)	NIOSH Method 1003
Tetrachloroethene (PCE)	NIOSH Method 1003
1,1-Dichloroethane (1,1-DCE)	NIOSH Method 1003
Chloroform ($CHCl_3$)	NIOSH Method 1003
1,1,1-Trichloroethane (1,1,1-TCA)	NIOSH Method 1003
Benzene	NIOSH Method 1501
Trichloroethene (TCE)	NIOSH Method 1022
Vinyl Chloride	NIOSH Method 1015

All of the personal charcoal filters tube air sample analyses resulted in the nondetection of the eight (8) suspected volatile organic compounds.

Well Bore Ambient Air Analysis

Two (2) well bore ambient air samples were collected in Tedlar bags from the upper and lower head space of monitoring well MW-8 and analyzed for volatile organic compounds utilizing EPA SW-846 Method 8240. The analytical results from the well bore ambient air samples did not indicate an exceedance of exposure criteria.

IV. BACKGROUND ASSESSMENT MONITORING

4.1 Introduction

Independent assessment monitoring result reports have presented the results of the four background and first annual comprehensive sampling event for Assessment Groundwater and Surface Water Monitoring at the Watauga County Landfill. All Assessment monitoring was performed in accordance with the Watauga County Landfill Assessment Plan (DAA, September 3, 1993). Appendix I of the Assessment Plan, The Groundwater and Surface Water Monitoring Program, details the schedule and procedures to be implemented for collecting groundwater and surface water samples, analyzing the samples for specified parameters, and evaluating and reporting the resultant water quality data.

Volume I of the monitoring results reports discuss sampling procedures, analytical results, and overall conclusions of the initial Assessment background sampling event. Volume II of the reports (under separate cover) contain copies of all associated laboratory data. Volume II of the monitoring results reports also contain Data Validation Forms summarizing the guidelines and results of the data validation procedures utilized for evaluating the data discussed in the reports.

4.1.1 Groundwater Monitoring Well Network

Eighteen (18) groundwater monitoring wells comprise the assessment groundwater monitoring well network at the Watauga County Landfill. Monitoring well locations are shown on the Groundwater and Surface Water Monitoring Program site map (Figure 2).

In order to maximize the effectiveness and efficiency of the Groundwater Monitoring Program, the assessment well network is stratified into two groups of "core" and "boundary" wells. Core assessment wells are selected based on the well's ability to monitor and characterize migration of contaminants. Boundary assessment wells are selected based on the well's ability to monitor and characterize the horizontal and vertical extent of the contaminants.

The decision criteria utilized for the selection of core assessment wells is the exceedance of the groundwater protection standard for an individual parameter. The groundwater protection standard is based on an individual parameter's North Carolina Groundwater Quality Standard (NCS) or EPA Maximum Contaminant Level (MCL).

The decision criteria utilized for the classification of boundary wells in the assessment monitoring well network is the exceedance of the analytical method limit of detection as determined by the laboratory for parameters identified as target parameters in the core assessment monitoring wells. The presence of target parameters above the analytical method limit of detection shall be evaluated with respect to repeated sampling events prior to confirmation.

Eleven (11) of the eighteen (18) groundwater monitoring wells were ~~recently~~ installed in January and February of 1994. For the first quarter background event, four (4) of the previous seven (7) monitoring wells, MW-2, MW-3, MW-4, and MW-6, were denoted as core assessment wells based on the decision criteria and available data. The upgradient well MW-1 was also evaluated similarly for purposes of comparison. All other assessment monitoring wells were initially denoted as boundary assessment wells for this initial assessment background sampling event.

Based on the decision criteria and the analytical data obtained from the first quarter background event, the assessment monitoring well network was restratified for the following background monitoring events. Revisions to the network of core and boundary assessment wells resulted in the upgrading of six of the eleven recently installed monitoring wells to "core" status (MW-8, MW-9, MW-10, MW-11, MW-12, and MW-17).

Upon review of the analytical data obtained from all four (4) background events, two additional monitoring wells, MW-4 and MW-7, were also restratified for the recent initial semi-annual monitoring event. MW-7 was upgraded to "core" status and MW-4 was downgraded to "boundary" status.

The assessment monitoring well network is currently classified as follows:

CORE WELLS	BOUNDARY WELLS
MW-1	MW-4
MW-2	MW-5
MW-3	MW-13
MW-6	MW-14
MW-7	MW-15
MW-8	MW-16
MW-9	MW-18
MW-10	
MW-11	
MW-12	
MW-17	

The Assessment Monitoring schedule (Table 1, Appendix 1) defines the monitoring requirements established for core and boundary assessment wells.

4.1.2 Surface Water Sampling Locations

The goal of the surface water monitoring system at Watauga County Landfill is to provide representative surface water samples for assessing the potential impact of landfill runoff and leachate on the streams located downgradient of the waste disposal area. Five (5) surface water monitoring points, combined with the sampling of any observed leachate production, serve to provide this objective.

- (S-1) The last of the series of sediment ponds is sampled to provide a representative sample for assessing the quality of the surface water originating from the landfill before the water discharges into the stream.

- (S-2) The spring capture outfall located adjacent to the last of the series of sediment ponds is sampled to provide a representative sample for assessing the quality of the water originating from the spring capture system located beneath the fill area.

- (S-3) The stream is sampled at the landfill property boundary (approximately 600 feet below the last sediment pond) to provide a representative sample for assessing the water quality of the stream below the waste disposal area. No sampling location is available upstream of the waste disposal area since the stream originates immediately below the adjacent tot he disposal area.

- (S-4) The stream located below the Bolick site is sampled approximately thirty (30) feet below the landfill property boundary to provide a representative sample for assessing the water quality of the surface water below the Bolick site. This sampling location is chosen instead of the sediment pond located on the Bolick site to provide a sample that is more representative of the potential influence of groundwater from the soil aquifer.

- (S-5) A seep, located below the waste disposal area and directly above the sediment pond, was observed flowing during the first quarter background event. This seep is sampled in addition to the four (4) originally proposed surface water sampling locations when observed flowing during routine surface water sampling events.

As outlined in the Assessment Monitoring schedule (Table 1, Appendix I), surface water samples are analyzed semi-annually utilizing CLP statements of work .

In addition to these five surface water sampling locations, any leachate production observed during surface water sampling events is also sampled. A grid field screening inspection of the landfill was conducted concurrent with the sampling events to verify the presence or absence of leachate production. Leachate production was observed and sampled on two of five sampling events. Observations resulting from the inspection is documented in the field notes found in the Appendix of each individual monitoring results report. Leachate analyses results can be found on the Analytical Results summary tables (Table 5B, Appendix I).

4.1.3 Sampling and Analysis Schedule

Groundwater

During the first year of Assessment groundwater monitoring, four (4) quarterly sampling events were conducted on each groundwater monitoring well. Semi-annual sampling events will be conducted after the first year. The first semi-annual Assessment monitoring event (also the first *annual comprehensive* Assessment Monitoring event) was recently conducted on July 10-13, 1995. The groundwater Assessment monitoring schedule is outlined in Table 1.

The analytical scans performed on each monitoring well during the first year of assessment background groundwater monitoring were designed to analyze for all the target parameters detected and tentatively confirmed as a result of the initial comprehensive sampling event performed on the previously existing monitoring well network MW-1 through MW-7 on March 5, 1993. The initial March 5, 1993 sampling event was comprised of the complete EPA Appendix II List of Hazardous Inorganic and Organic Parameters (40 CFR, Part 258) currently required for Assessment Monitoring under the North Carolina Department of Environment, Health, and Natural Resources (NCDEHNR) requirements for Municipal Solid Waste Landfills (15A NAACO 13B Section .1600). A summary and evaluation of the results of the initial March 5, 1993 sampling event are detailed in Sections II and III of the Assessment Plan (DAA, September 3, 1993).

The Assessment Plan specifies that after completion of the four (4) quarterly Assessment background groundwater monitoring events and on an annual basis thereafter, the complete EPA Appendix II analysis will be repeated on the revised network of core assessment wells. The first annual comprehensive Assessment Monitoring event was recently conducted on July 10-13, 1995 and is described herein. If any additional parameters are detected, and verified through QA/QC validation as being present, that were not identified in prior Assessment monitoring events, amendments to the existing target parameter list will be evaluated and reviewed with the NCDEHNR. For amended target parameters, four (4) independent samples will be collected and analyzed for those additional parameters during the following four (4) semi-annual sampling events at all core and boundary assessment wells to establish background.

Groundwater monitoring events will also continue to be conducted on all wells on a semi-annual basis for the target parameters detected as a result of the complete EPA Appendix II analysis. Reevaluation of the site network and monitoring scheme will be conducted after review of the results of each sampling event. Proposed revisions to the Assessment monitoring program for the second semi-annual Assessment monitoring program are contained herein Section 4.8.5.

The groundwater monitoring program follows a two-tiered analytical approach utilizing both EPA Contract Laboratory Program Statement of Work (CLP SOW) - Organic and Inorganic analytical methods, and low level risk assessment (LLRA) screening by EPA-SW846 analytical methods. The CLP SOWs are utilized to generate high-level quality data with documented QA/QC protocols. The LLRA methods (EPA-SW-846) are utilized for risk assessment screening to preliminary identify low levels of parameters that may be present. The groundwater analysis schedule, indicating methods designated for the core and boundary wells, is outlined in Table 1.

During the first year of Assessment Monitoring, analyses of the core assessment monitoring wells utilized CLP SOWs for all four (4) quarterly events. Organic analyses of the boundary assessment monitoring wells alternated between CLP and LLRA analytical methods for each quarterly event.

After the first year of quarterly background sampling events, the core assessment monitoring wells are scheduled to be monitored on a semi-annual basis. The first semi-annual core sampling event analyzed for all the assessment monitoring parameters included in the EPA Appendix II List of Hazardous Inorganic and Organic Parameters (40 CFR Part 258) utilizing LLRA analytical methods. The second semi-annual core sampling event will also analyze for the target parameter assessment monitoring parameters using CLP-SOWs.

After the first year of quarterly sampling events, boundary assessment wells are scheduled to be monitored on a semi-annual basis for the target parameter assessment monitoring parameters. Analysis of semi-annual boundary well monitoring events is scheduled to alternate between CLP and LLRA methods for each semi-annual event.

Surface Water

Surface water and leachate monitoring was conducted on a semi-annual basis during the first year of the Assessment Plan groundwater monitoring program and is scheduled to continue semi-annually thereafter. The analytical scans that will be performed on the surface water and leachate samples will utilize CLP SOW and will be designed to analyze for all the target parameters detected as a result of the annual comprehensive Appendix II analysis. The surface water assessment monitoring schedule is outlined in Table 1.

4.2 Groundwater And Surface Water Sampling Field Procedures

Groundwater and surface water samples were collected according to the Watauga County Landfill Groundwater and Surface Water Monitoring Plan (DAA, September 3, 1993), to insure representative samples were collected, received by the laboratory and subject to analysis. Field notes, contained in Appendix II of all the individual background monitoring reports, document groundwater sample collection procedures.

4.2.1 Well Purging and Sample Collection

Dedicated stainless steel and TEFLON electrical submersible pumps were permanently installed in the new well network subsequent to the first event. Environmental Technicians from Draper Aden Associates used the dedicated pumps to purge and collect groundwater samples from the monitoring well network. All non-dedicated equipment was decontaminated between sampling of each monitoring well.

A minimum of three well volumes of groundwater, inclusive of water residing in the well casing and filter pack, were removed from each monitoring well prior to sample collection. A well volume was calculated from measurements of depth to water, and total well depth taken prior to purging. Stabilization of field analyses for pH and Specific Conductivity were used to verify that stagnant water within the well was removed during purging, and that groundwater representative of the near-aquifer was being sampled. Field notes recorded during each sampling event summarize and document well purging calculations and results.

4.2.2 Field Meter Calibration

Measurements of pH and Specific Conductivity were analyzed at each well by completing multiple measurements in the field, at the time of groundwater purging. Although pH and Specific Conductivity are not assessment monitoring parameters, the measurements were used to ensure groundwater quality and stabilization.

A Corning Checkmate 90 pH/Conductivity/Temperature meter was used for the field measurement of pH, and conductivity. The meter was calibrated in the field using laboratory-grade buffers for pH, and KCl solution for Specific Conductivity. Field notes included in Appendix II of each individual monitoring results report document field meter calibration methods for each sampling event.

4.2.3 Quality Control Blank Samples

Due to the use of dedicated purging and sampling equipment for each monitoring well, field blanks were not collected.

Trip Blanks were utilized as part of the assessment monitoring program. Trip Blanks were prepared by the analyzing laboratory to accompany the sample kits at all times. The Trip Blanks employed sample containers and volumes identical in physical and chemical integrity to the samples used for actual sample collection. The Trip Blank was analyzed for all parameters included in the sampling event. The Trip Blank served as a control on sample kit preparation, analysis in the laboratory, and sample kit transportation.

control the precision and accuracy of the data sets to be compared by use of field audit samples.

The CLP SOWs are utilized to generate a high level quality data with documented QA/QC protocols. The SW-846 methods are utilized to generate organic data for risk assessment to preliminary identify low levels of analytes that may be present. Estimated CLP SOW results, between the Instrument Detection Limit (IDL) and the Contract Required Detection Limit (CRDL) for Inorganics, and less than the Contract Required Quantitation Limit (CRQL) for Organics, are similarly provided for preliminary assessment purposes only. Estimated data is not intended for use in determining regulatory compliance issues.

Analytical Procedures

Analytical methods and detected parameters for the background and first semi-annual assessment monitoring events, described herein, are provided in the Assessment Monitoring Results Summary Tables in Appendix I herein.

Internal Quality Control

i. **Field Quality Control** - Field Quality Control procedures are summarized in the previous section of this report.

ii. **Analytical Quality Control** - Analytical Quality Control procedures for CLP analytical techniques are guided by adherence to Contract Laboratory Program (CLP) deliverables. All quality control data and records generated by the laboratory were examined by Draper Aden Associates for adherence to method requirements. A laboratory quality control report generally consists of the following components:

- spikes
- blanks
- duplicates
- surrogate parameters
- instrument adjustment
- calibration
- additional QC requirements (organic and inorganic)
- quantification
- raw data
- chromatograms

For this project, QC reports are provided with the target parameter analytical results for all sampling events.

4.4 Data Validation

The CLP analyses for organic as well as inorganic parameters were performed in adherence to the relevant Contract Laboratory Program-Statement of Work (CLP-SOW). LLRA analyses for organic parameters were performed in adherence to relevant SW-846 method requirements and guidance. Results of the CLP-SOW analyses were summarized and reported by the analyzing laboratory in standard CLP reporting format. Draper Aden Associates conducted data validation of each data set. The results from each sampling event were evaluated in association with corresponding QA/QC information provided by the analyzing laboratory.

4.4.1 Laboratory Reporting Qualifiers

Two different types of qualifiers were associated with laboratory analyses and data validation: they were **laboratory reporting qualifiers** and **data validation qualifiers**.

The laboratory used **laboratory reporting qualifiers** to flag sample results with reference to relevant QA/QC criteria. Laboratory reporting qualifiers were unique to the analyzing laboratory and are defined in the laboratory data package presented in volume II of this report. The defined **organic** laboratory reporting qualifiers are not equivalent to the defined **inorganic** laboratory reporting qualifiers and review of the definitions is recommended. In addition to the laboratory reporting qualifiers defined in volume II, project specifications required the laboratory performing the analytical services to utilize the following additional data qualifiers and definitions:

<u>Qualifiers</u>

D - Denotes the sample was diluted to obtain the result.
S - Method of Standard Additions was utilized to obtain the result.
E - Laboratory recoveries fell outside EPA control limits. Results are approximate concentrations.
TI - The laboratory tentatively identified the parameter.

<u>Definitions</u>

CRDL. Contract Required Detection Limit (associated with CLP-inorganics only).

IDL. Instrument Detection Limit (Associated with CLP-inorganics only). Inorganic Data qualified with a "U" refers to IDL.

CRQL. Contract Required Quantitation Limit (associated with CLP organics only). Organic Data qualified with a "U", refer to CRQL.

4.4.2 Data Validation Qualifiers

Data validation was completed using guidance from the "USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review", (Document 1) USEPA, February, 1993; and "USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review - February 1994" (Document 2).

Data Validation was performed on the results presented in the laboratory analysis report, and the validated results were flagged, where required, using the appropriate national **data validation qualifiers** defined from the aforementioned CLP guidance documents. The data validation qualifiers were divided into two categories; **organic** data validation qualifiers and **inorganic** data validation qualifiers. The **data validation qualifiers** (as defined in Documents 1 and 2 above) are different from the **laboratory reporting qualifiers**. Definitions of the nationally recognized data validation qualifiers used by Draper Aden Associates in the validation process and for the reported results are presented below.

<u>Organic Data Validation Qualifiers</u>

U - The parameter was analyzed for, but was not detected above the reported sample limit of quantitation (LOQ).

J - The parameter was positively identified; the associated numerical value is the approximate concentration of the parameter in the sample.

N - The analysis indicates the presence of an parameter for which there is presumptive evidence to make a "tentative identification".

NJ - The analysis indicates the presence of an parameter that has been "tentatively identified" and the associated numerical value represents its approximate concentration.

UJ - The parameter was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the parameter in the sample.

R - The sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the parameter cannot be verified.

Inorganic Data Validation Qualifiers

U - The material was analyzed for, but was not detected above the level of the associated value. The associated value is the sample detection limit.

J - The associated value is an estimated quantity.

R - The data are unusable. (Note: Parameter may not be present)

UJ - The material was analyzed for, but was not detected. The associated result is an estimate and may be inaccurate or imprecise.

4.5 **Discussion Of Analytical Results**

Tables 2A-D and tables 5A-5C (Assessment Target Parameter Analytical Results; Appendix I) provide a summary of the target parameter analytical results obtained from the first annual comprehensive sampling event and the four background monitoring events, respectively. These results were validated in-house by Draper Aden Associates according to the discussion provided in Sections III and IV of each respective monitoring report. the analytical summary tables lists for each parameter, as applicable, a Maximum Contaminant Level (MCL) established by the USEPA and groundwater quality standards established by the state of North Carolina (NCS), the Instrument Detection Level (IDL) for CLP-Inorganic results, the Contract Required Detection Limit (CRQL) for CLP-Organic results, the Limit of Quantitation (LOQ) for LLRA-Organic results, and the analytical method.

Estimated analytical results for the target parameters are provided in the summary tables for preliminary assessment purpose only. Estimated analytical data is not intended for use in determining regulatory compliance issues.

A summary of additional non-target parameter analytical results obtained from the first annual comprehensive sampling event is provided in Tables 3A and 3B, for organic and metal parameters, respectively. A summary of additional non-target parameter analytical results obtained from the four background sampling events is provided in Tables 6A and 6B. Non-target parameter data is provided for preliminary assessment purpose only and is not intended for use in determining regulatory compliance issues.

4.5.1 Inorganic Analytical Results

i. Target Inorganic Parameter

The evaluation of existing inorganic data on twelve (12) metal parameters, collected prior to development of the Assessment Plan, indicated the tentative presence of four (4) metals at elevated concentrations in the groundwater beneath the Watauga County Landfill. Previous metal concentrations detected in the groundwater are generally low or are below analytical method quantitation limits. However, two metals, Cadmium and Iron, were historically observed at levels above those established by the EPA MCL and Secondary MCL, respectively. Barium, a common naturally occurring parameter, was also observed at relatively elevated levels, but below water quality standards. Mercury was also detected, although only once for each well in the six or more sampling and analysis events previously conducted.

The analytical results for the four target metal parameters, Barium, Cadmium, Iron, and Mercury, obtained from the four background and the first semi-annual assessment sampling event discussed below. A discussion of parameter distribution trends for each target parameter is presented in the following Section 4.6.

The two metal target parameters, Barium and Iron, both common naturally occurring parameters, have been detected in all monitoring wells and surface water sampling locations, as a result of the previous background Assessment monitoring events (Table 5C). Although observed in all of the monitoring wells and surface water sampling locations, Barium was detected at levels below the EPA MCL and North Carolina groundwater standard of 2,000 µg/l as a result of all four background Assessment background monitoring events. Concentrations of Iron were often at levels significantly above associated water quality criteria. No Federal Primary Drinking Water Standard (EPA MCL) exists for Iron. Similar Barium and Iron concentrations were observed as a result of the first semi-annual assessment monitoring.

Review of Tables 2A and 2B indicates the first semi-annual total Cadmium and total Mercury CLP analysis resulted in the non-detection of Cadmium and Mercury in all eighteen (18) monitoring wells and five (5) surface water sampling locations sampled. Since Cadmium and Mercury were also not detected as a result of the initial four (4) background assessment monitoring analyses, Cadmium and Mercury will be deleted from the existing target parameter list.

The analytical results for fifteen (15) non-target metal parameters obtained from the first semi-annual assessment sampling event (also the first *annual comprehensive event*) are summarized in Table 3B and also discussed below. A discussion of parameter distribution trends for all detected non-target metal parameters is presented in Section 5.4.2.

ii. Non-Target Inorganic Parameters

The comprehensive analysis of fifteen (15) non-target metal parameters resulted in the non-detection of the following eight (8) metals:

- Antimony
- Arsenic
- Beryllium
- Cyanide
- Selenium
- Silver
- Thallium and
- Tin

The following three (3) metals were only observed in one core monitoring well, MW-3, and at levels far below EPA MCL and North Carolina groundwater standards:

- Copper
- Lead
- Zinc

The remaining four (4) metals were observed in three (3) or more core monitoring wells, although also at levels far below EPA MCL and North Carolina groundwater standards.

- Chromium
- Cobalt
- Nickel
- Vanadium

These four (4) metals will be added to the existing target parameter list. Four (4) independent samples will be collected and analyzed for these four (4) metals during the following four (4) semi-annual sampling events at all core and boundary assessment wells to establish background.

Sulfide was also included in the first comprehensive events analysis. Sulfide was only observed in one core monitoring well, MW-4, and only detected in MW-4 at a concentration equal to the detection limit. Since no organic compounds or elevated metal levels have been previously detected in MW-4 (note: MW-4 was recently downgradient to boundary status, see Section I.), it is unlikely that the Sulfide detected in MW-4 is a related groundwater impact.

4.5.2 Organic Analytical Results

i. Target Organic Parameters

The evaluation of existing organic data, compiled prior and during development of the Assessment Plan, indicated the tentative presence of twelve (12) primary target organic parameters occurring in the groundwater beneath the Watauga County Landfill. The background analytical results obtained for each target organic parameter is individually discussed below. A discussion of distribution trends for each target organic parameter is presented in the following Section 4.6.

<u>1,1-Dichloroethane (1,1-DCA)</u>

1,1-Dichloroethane (1,1-DCA) was detected at concentrations below the proposed North Carolina groundwater standard (NCS) of 700 μg/l in ten core groundwater monitoring wells (MW-2, MW-3, MW-6, MW-7, MW-8, MW-9, MW-10, MW-11, MW-12 and MW-17). No EPA MCL exists for 1,1-DCA. 1,1-Dichloroethane was observed (estimated below the method LOQ) on only one sampling event in two boundary monitoring wells (MW-13 and MW-15). Concentrations of 1,1-DCA (detected both above and below the method CRQL) were also observed below the NCS at four surface water sampling locations (S-1, S-2, S-4, and S-5.)

<u>Tetrachloroethene (PCE)</u>

Tetrachloroethene (PCE) was detected at concentrations above the EPA MCL of 5 μg/l and above the North Carolina groundwater standard (NCS) of 0.7 μg/l in eight core groundwater monitoring wells (MW-2, MW-3, MW-6, MW-8, MW-10, M-11, MW-12, and MW-17) and one surface water sampling location (S-4). Tetrachloroethene (PCE) was detected at concentrations equal to (SW-846 method 8021) and below (SW-846 method 8260) the EPA MCL of 5 μg/l and above the North Carolina groundwater standard (NCS) of 0.7 μg/l in one additional core groundwater monitoring well (MW-9). PCE was not detected in any of the boundary monitoring wells .

<u>Trichlorcethene (TCE)</u>

Trichloroethene (TCE) was detected at concentrations above the EPA MCL of 5 μg/l and above the NCS of 2.8 μg/l in seven core groundwater monitoring wells (MW-3, MW-6, MW-8, MW-9, MW-11, MW-12, and MW-17). Estimated concentrations for TCE (detected below the method CRQL) were observed above the EPA MCL and above the NCS in one surface water sampling location (S-4) utilizing CLP methods. TCE was also observed (detected below the method LOQ/CRQL) at concentrations below the EPA MCL and NCS in two additional core groundwater monitoring wells (MW-2 and MW-7) and one additional surface water sampling location (S-2). TCE was not detected in any of the boundary monitoring wells.

cis-1,1-Dichloroethene (cis-1,2-DCE)

CLP-SOW analytical results for cis-1,2-Dichloroethane are reported as part of a total concentration of cis- and trans- isomers of the parameter.

Cis-1,2-Dichloroethene (cis-1,2-DCE) was detected at concentrations above the EPA MCL and North Carolina groundwater standard (NCS) of 70 μg/l in three core groundwater monitoring wells (MW-6, MW-8, and MW-17). Cis-1,2-DCE was also detected below the EPA MCL and NCS in five additional core monitoring wells (MW-3, MW-7, MW-9, MW-11, and MW-12). Total 1,2-DCE was also observed (detected above the method CRQL) at a concentration below the EPA MCL and NCS at one suffice water sampling location (S-4).. Estimated concentrations for total 1,2-DCE (detected below the method CRQL) were observed below the EPA MCL and NCS at two additional surface water sampling locations (S-1 and S-2).

Dichlorodifluoromethane

Concentrations for Dichlorodifluoromethane (detected both above and below applicable method LOQs) were observed above the North Carolina groundwater standard (NCS) of 0.19 μg/l in seven core groundwater monitoring wells (MW-3, MW-6, MW-8, MW-9, MW-11, MW-12, and MW-17). Estimated concentrations for Dichlorodifluoromethane (detected below the method CRQL) was also observed above the North Carolina groundwater standard (NCS) of 0.19 μg/l at two surface water sampling locations (S-2 and S-5) on only one sampling event. No EPA MCL exists for Dichlorodifluoromethane. Dichlorodifluoromethane was not detected in any of the boundary monitoring wells.

1,1,1-Trichloroethane (1,1,1-TCA)

1,1,1-Trichloroethane (1,1,1-TCA) was detected at concentrations above the EPA MCL and North Carolina groundwater standard (NCS) of 200 μg/l in two core monitoring wells (MW-2 and MW-10). 1,1,1-TCA was also detected below the EPA MCL and NCS in six additional core monitoring wells (MW-3, MW-8, MW-9, MW-11, MW-12, and MW-17) and two additional boundary groundwater monitoring wells (MW-14 and MW-15).. Estimated concentrations of 1,1,1-TCA (below the method CRQL) were also observed below the EPA MCL and NCS at two surface water sampling locations (S-2 and S-4).

1,1-Dichloroethene (1,1-DCE)

1,1-Dichloroethene (1,1-DCE) was detected above the method LOQ at concentrations above the EPA MCL and NCS of 7 μg/l in two core groundwater monitoring wells (MW-2 and MW-10). . 1,1-DCE was also detected (observed both above and below applicable method LOQs and CRQLs) at concentrations below applicable water quality standards in six additional core wells (MW-3, MW-6, MW-8, MW-11, MW-12, and MW-17). 1,1-DCE was not detected in any of the boundary monitoring wells or surface water samples.

Benzene

Concentrations of Benzene were observed above the EPA MCL of 5 µg/l and above the NCS of 1 µg/l in two core groundwater monitoring wells (MW-6 and MW-8). Benzene was also detected below the EPA MCL but above the NCS in three additional core groundwater monitoring wells (MW-3, MW-7, AND MW-9). Benzene was also detected (estimated below the CRQL) in only one sampling event in MW-17. Benzene was not detected at any of the boundary wells or surface water sampling locations .

Vinyl Chloride

Concentrations of Vinyl Chloride (detected both above and below applicable LOQs and CRQLs) were observed at concentrations above the EPA MCL of 2 µg/l and above the North Carolina groundwater standard (NCS) of 0.015 µg/l in five core groundwater monitoring wells (MW-3, MW-6, MW-7, MW-8, and MW-12). Estimated concentrations of Vinyl Chloride (detected below the CLP method CRQL) was observed at levels above the EPA MCL of 2 µg/l and above the North Carolina groundwater standard (NCS) of 0.015 µg/l at one surface water sampling location (S-4). A low level concentration of Vinyl Chloride (detected below the method LOQ utilizing SW-846 method 8021) was also observed on only one sampling event in one additional groundwater monitoring well (MW-17) below the EPA MCL but above the NCS.

Methylene Chloride

Methylene Chloride has been observed rather sporadically among the past five assessment monitoring events. Methylene Chloride was observed above the EPA MCL and NCS of 5 µg/l for all of the past five assessment monitoring events in only one core groundwater monitoring well (MW-9). Methylene Chloride was detected sporadically in ten other wells. During the recent annual comprehensive monitoring event, Methylene Chloride was detected (observed both above and below the method LOQ) at concentrations below the EPA MCL and NCS in six core groundwater monitoring wells (MW-3, MW-6, MW-8, MW-11, MW-12, and MW-17) and two boundary groundwater monitoring wells (MW-13 AND MW-18) utilizing SW-846 method 8021, although not detected in any other groundwater monitoring wells utilizing SW-846 method 8260.

Methylene Chloride was observed (estimated below the CRQL) at all the surface water sampling locations on the first background sampling event, but has not been detected in the surface water in the four subsequent monitoring events.

Chloroethane

Chloroethane was detected in seven core groundwater monitoring wells (MW-3, MW-6, MW-7, MW-8, MW-9, MW-12, and MW-17) and at three surface water sampling locations (S-1, S-4, and S-5). No EPA MCL or North Carolina groundwater standard (NCS) exists for Chloroethane.

trans-1,3-Dichloropropene

Trans-1,3-Dichloropropene was not detected in any monitoring wells or surface water samples

ii. Non-Target Organic Parameters

The analytical results of additional detected non-target organic parameters are summarized in Tables 3A, 6A and 6B. The analytical results obtained for non-target parameters, are provided to preliminarily identify those parameters which may need to be continually monitored. If upon completion of background data collection, the presence of any non-target parameters are confirmed by repeated analysis, the parameter will be added to the Target Parameter list. As discussed below, the presence of no non-target parameters have been confirmed by repeated analysis.

Additional non-target parameters were detected in seventeen of the eighteen monitoring wells and two surface water sampling locations, although none of the detected non-target parameters appear persistent or pervasive within the assessment monitoring well network. For the past five monitoring well analyses, a total of seven non-target parameters were detected utilizing SW-846 method 8260 and fifteen non-target parameters were detected utilizing SW-846 method 8021. Six of the fifteen non-target parameters detected by method 8021 were also detected by method 8260. For the surface water analyses, five non-target parameters were detected utilizing CLP SOPs. Detected non-target parameters and associated sampling points are presented below.

Detected Non-target Parameter(s)	Monitoring Point(s)
Acetone	MW-1, 7, & MW-10
Carbon Tetrachloride	MW-4, 12, & MW-17
Trichlorotriflouromethane	MW-3 & MW-9
Dibromochloromethane	MW-14
Bromomethane	MW-1 & MW-3
1,1,2,2-Tetrachloroethane	MW-1
trans-1,2-Dichloroethene	MW-3, 6, 7, 8, 12 & MW-17
1,2-Dichloroethane	MW-3, 8, & MW-17
1,2-Dichloropropane	MW-3, 6, 7, 8 & MW-17
1,4-Dichlorobenzene	MW-8
2-Butanone	MW-7, 8, 10, & S-2

2-Methyl-2-Pentanone	MW-1 & S-2
Styrene	MW-9 & MW-12
Napthalene	MW-7, 9, 12, 13, & MW-16
o-Xylene	MW-7 & MW-9
m/p-Xylene	S-1
total Xylene	MW-1, 7, 9, & S-2
Toluene	MW-1, 4, 12 , 17 & S-2
Ethylbenzene	MW-1 & S-2
1,2,3-Trichlorobenzene	MW-12 & MW-13
1,4-Dichlorobenzene	MW-8
1,3,5-Trimethylbenzene	MW-9
n-Propylbenzene	MW-9, 12, & MW-16

As indicated in Tables 3A, 6A and 6B in Appendix I (Detected Non-target Organic Parameter Analytical Results), the presence of these detected non-target compounds are not confirmed by the analytical results obtained from repeated background sampling events. Confirmation of the presence or absence of these non-target parameters as well as tentatively identified compounds will continue to be evaluated on the following semi-annual monitoring events.

4.6 Parameter Distribution Trends

4.6.1 Inorganic Analytical Results

Mercury (total)

The presence of Mercury in the groundwater at the site is not supported by the analytical results of all four assessment background monitoring events and the first comprehensive annual EPA Appendix II List sampling event. No concentrations of Mercury were observed above the IDL of 0.20 µg/l. Since Mercury is confirmed to be absent, Mercury will be removed from the target parameter list.

Cadmium (total)

The presence of Cadmium in the groundwater at the site is not supported by the analytical results of all four assessment background monitoring events and the first comprehensive annual EPA Appendix II List sampling event. The recent comprehensive event detected no concentrations of Cadmium observed above the IDL of 0.5 µg/l. The only Cadmium detected in all four background events was detected in the low production well MW-7 (12.3 µg/L) on the fourth background sampling event. The three previous background sampling events resulted in the non-detection of Cadmium in MW-7. Since Cadmium is confirmed to be absent, Cadmium will be removed from the target parameter list.

Barium (total)

Barium distribution trends, indicated by the analytical results of the background assessment monitoring events, suggest a relationship between Barium distribution and proximity to both the waste disposal area and the west drainage. Although Barium was detected at every point sampled, half of the Barium detected in the groundwater at the site was reported at concentrations less than 100 μg/l. The EPA MCL and the NCS for Barium is 2000 μg/l.

Iron (total)

Iron distribution trends, indicated by the analytical results of the background assessment monitoring events, also indicate a relationship between Iron distribution and proximity to the waste disposal area. The monitoring wells for which Iron was observed at the highest concentrations, MW-6 and MW-3, are located adjacent and west of the waste disposal area, respectively. Iron was also observed at elevated levels in MW-10, located in the drainage directly below the waste disposal area; MW-1, located adjacent and upgradient of the waste disposal area; and MW-8, located adjacent and west of the waste disposal area. Elevated concentrations of Iron above 1000 μg/l were also detected in all the surface water monitoring locations.

4.6.2 Organic Analytical Results

i. Target Organic Parameters

The following section discusses the distribution trends of individual target parameters. Distribution similarities are identified and utilized to assist in characterizing parameter transport, migration, and fate responses.

1,1-Dichloroethane (1,1-DCA)

1,1-Dichloroethane (1,1-DCA) was observed at elevated concentrations in more monitoring wells and occurs more pervasively throughout the site than any other target parameter. No established EPA MCL or NCS exists for 1,1-DCA.

1,1-DCA was observed at the highest concentrations (although below the proposed North Carolina groundwater quality standard of 700 μg/l) in the nested well pair, shallow MW-3 and deep well MW-17, located at the downgradient property boundary of the Bolick site. Elevated concentrations of 1,1-DCA were also observed between the landfill and the Bolick site at MW-6 and within the Bolick site at MW-8, and downgradient of the Bolick site at the nested well pair, shallow well MW-11 and deep well MW-12.

Elevated concentrations of 1,1-DCA were also observed in the deep well MW-10, located below the waste disposal area, and the deep well MW-2, located in the drainage below the waste disposal area. 1,1-DCA was not detected in the shallow wells MW-4 and MW-16, located in the northern drainage basin below the landfill. Elevated concentrations of 1,1-DCA were also observed at MW-9, located along the southern saddle above the landfill. Lower level concentrations of 1,1-DCA were observed at MW-7, located south of the Bolick site.

Tetrachloroethene (PCE)

With few exceptions, Tetrachloroethene (PCE) was detected primarily along the west drainage basin adjacent to the landfill, located within and below the "Bolick" site. PCE distribution trends are similar to TCE, cis-1,2-DCE and Dichlorodiflouromethane distribution trends.

PCE was detected at concentrations above the EPA MCL in the nested well pair located at the downgradient property boundary of the Bolick site; i.e.: shallow well MW-3 and deep well MW-17. PCE was also detected downgradient of the Bolick site at concentrations above the EPA MCL in the nested well pair located below the Boone-Nissan septic field; i.e.: shallow well MW-11 and the deep well MW-12. PCE was similarly detected above the EPA MCL in MW-8, located with the Bolick site, and in MW-6, located between the landfill and the Bolick site.

PCE was also detected at concentrations above the EPA MCL (5 μg/l) in the surface water sampling location situated in the west drainage , i.e.: S-4.

Other PCE detections were observed at lower concentrations above the EPA MCL in MW-2 and in MW-10, located within the bedrock aquifer in the drainage below the waste disposal area. PCE was not detected in the shallow soil wells, MW-4 and MW-16, located in the northern drainage basin below the landfill.

Trichloroethene (TCE)

With only one exception (MW-9, located along the southern saddle), Trichloroethene (TCE) was only detected along the west drainage basin adjacent to the landfill, located within and below the Bolick site. As discussed previously for PCE, TCE distribution trends are similar to PCE, cis-1,2-DCE, and Dichlorodiflouromethane distribution trends.

TCE was detected at the highest concentrations in monitoring well MW-6, located adjacent to the landfill, within the Bolick site. Elevated concentrations for TCE were also observed in the deeper well adjacent to MW-6, MW-8. Elevated concentrations for TCE were also observed in the nested well pair located at the downgradient property boundary of the Bolick site; i.e.: shallow well MW-3 and deep well MW-17. TCE was also detected downgradient of the Bolick site in the nested well pair located below the Boone-Nissan septic field; i.e.: deep well MW-12 and shallow well MW-11. TCE was detected only twice in MW-7, located immediately south of the Bolick site and adjacent and west of the disposal area.

The only TCE observed outside of the west drainage basin was detected in MW-9, located between the landfill and the Rocky Mountain Heights Subdivision.

cis-1,2-Dichloroethene (cis-1,2-DCE)

With one exception (MW-9), Cis-1,2-Dichloroethene (cis-1,2-DCE) was only detected along the west drainage basin adjacent to the landfill, located within and below the Bolick site. As discussed previously for PCE and TCE, cis-1,2-DCE distribution trends are similar to PCE, TCE, and Dichlorodiflouromethane distribution trends.

Cis-1,2-DCE was observed at the highest concentrations (above the EPA MCL and NCS of 70 µg/l) in MW-6 and MW-8, located adjacent to the landfill and the Bolick site. Elevated concentrations of cis-1,2-DCE (below the EPA MCL and NCS) were also observed in the nested well pair located at the downgradient property boundary of the Bolick site i.e.: shallow well MW-3 and deep well MW-17 and downgradient of the Bolick site at the nested well pair, shallow well MW-11 and deep well MW-12.

Lower level detections of cis-1,2-DCE were observed at the two monitoring wells, MW-7, located south of the Bolick site, and MW-9, located along the southern saddle above the landfill.

As previously discussed, CLP-SOW analytical results for cis-1,2-Dichloroethene were reported as a total concentration of cis- and trans- isomers of the parameter. Total 1,2-Dichloroethene was detected at three surface water sampling locations; S-1, S-2, and S-4.

Dichlorodifluoromethane

As discussed previously for PCE, TCE, and cis-1,2-DCE, Dichlorodifluoromethane distribution trends are similar to PCE, TCE, and cis-1,2-DCE distribution trends.

Elevated concentrations of Dichlorodifluoromethane were observed in the west drainage in MW-3, MW-8, MW-11, MW-12, and MW-17 and in MW-9, located between the landfill and the Rocky Mountain Heights Subdivision. All of these Dichlorodifluoromethane detections were estimated at concentrations above the North Carolina groundwater standard (NCS) of 0.19 µg/l. No EPA MCL exists for Dichlorodifluoromethane.

1,1,1-Trichloroethane (1,1,1-TCA)

1,1,1-Trichloroethane (1,1,1-TCA), although pervasive throughout the core of the site, was observed at the highest concentrations in the bedrock of the northern drainage basin below the landfill.

1,1,1-TCA was consistently observed above the EPA MCL and NCS of 200 µg/l in the bedrock wells, MW-2 and MW-10, located in the northern drainage below the landfill. 1,1,1-TCA was notable absent from the shallow soil wells, MW-4 and MW-16, located with the same drainage, adjacent to and downgradient, respectively, of MW-2.

1,1,1-TCA was also observed at lower concentrations, below the EPA MCL and NCS, in both the deep and shallow wells of the two nested pairs located in the west drainage basin; shallow MW-3 and deep MW-17, and shallow MW-11 (estimated) and deep MW-12, at and downgradient of the Bolick Site property boundary, respectively. Estimated concentrations (below the respective LOQs/CRQLs) of 1,1,1-TCA was also observed in MW-8, located upgradient of these two nested pairs of wells in the west drainage basin.

1,1,1-TCA was additionally detected in MW-9, located adjacent to the Carroll property and in the nested boundary monitoring well set MW-14 and MW-15, located adjacent to Rocky Branch.

1,1-Dichloroethene (1,1-DCE)

Similar to 1,1,1-TCA, 1,1-Dichloroethene (1,1-DCE) was also observed at the highest concentrations in the bedrock of the northern drainage basin below the landfill.

The highest concentrations for 1,1-DCE were observed in the deep bedrock well MW-2, located in northern drainage basin below the landfill and in the bedrock well MW-10, located in the northern drainage directly below the fill areas. 1,1-DCE was not detected in the shallow soil wells, MW-4 and MW-16, located in the northern drainage basin below the landfill.

Monitoring wells located in the west drainage basin reveal either low level, estimated concentrations or the non-detection of 1,1-DCE. 1,1-DCE was observed below the method LOQ (estimated) for five monitoring wells located in the west drainage basin; MW-3, MW-6, MW-8, MW-12, and MW-17. 1,1-DCE was not detected in the shallow well MW-11, located adjacent to the deep well MW-12 in this west drainage basin.

Benzene

Benzene distribution trends suggest a relationship between Benzene distribution and proximity to both the waste disposal area and the west drainage.

Benzene was detected at concentrations above the EPA MCL (5 µg/l) and NCS (1 µg/l) in the nested well pair located adjacent and west of the disposal area., shallow well MW-6 and deep well MW-8, and in MW-2, located in the drainage below the waste disposal area.. Estimated Benzene concentrations between the lower North Carolina groundwater quality standard (NCS) and the higher EPA MCL were observed randomly distributed about the site in other core and boundary wells; MW-3, MW-4, MW-7, MW-9, MW-16, MW-17, AND MW-18..

Vinyl Chloride

Vinyl Chloride distribution trends are similar to Benzene distribution trends. A relationship is observed between Vinyl Chloride distribution and proximity to both the waste disposal area and the west drainage. Vinyl Chloride was repeatedly detected above the EPA MCL (2 µg/l) and NCS (0.015 µg/l) in the west drainage adjacent to the landfill in MW-6, located between the landfill and the Bolick site, and MW-8, located within the Bolick site. An estimated level of Vinyl Chloride was also detected above the NCS (0.015 µg/l) in MW-3, located in the west drainage at the downgradient property boundary of the Bolick site.

Methylene Chloride

A review of Methylene Chloride distribution trends reveal that Methylene Chloride has been sporadically observed at disparate locations. Although Methylene Chloride was repeatedly detected at the highest concentrations in MW-9, located adjacent to the Carroll Residence, between the landfill and the Rocky Mountain Heights Subdivision, Methylene Chloride was seldom detected more than once in other monitoring wells. The Methylene Chloride concentrations observed in MW-9 are significantly above the EPA MCL and North Carolina groundwater standard (NCS) of 5 µg/l. Other detections of Methylene Chloride, randomly observed in MW-2, MW-3, MW-6, MW-8, MW-10, MW-12, MW-16, and MW-18, were often at low levels near the applicable method detection levels.

Chloroethane

Review of the analytical from the past five assessment monitoring events reveals Chloroethane was observed at the highest concentrations in MW-9, located adjacent to the Carroll property, and well MW-7, located adjacent and south of the Bolick site. Elevated concentrations of Chloroethane were also observed in five core monitoring wells located in the west drainage; shallow well MW-3, located adjacent to deep well MW-17, deep well

MW-12, MW-6, located between the landfill and the Bolick site, and in MW-8, located within the Bolick site.

trans-1,3-Dichloropropene

The presence of trans-1,3-Dichloropropene in the groundwater at the site is not supported by the analytical results of the previous four background assessment monitoring events and the first comprehensive assessment monitoring event.

Since upon completion of background data collection and the first annual EPA Appendix II list sampling event (utilizing LLRA analytical methods), the absence of trans-1,3-Dichloropropene in the groundwater and surface waters at the site is confirmed, trans-1,3-Dichloropropene will be removed from the Target Parameter List.

ii. Non-target Organic Parameters

As previously discussed, individual non-target parameters were detected sporadically (Table 3A, Appendix I). As such, distribution trends are difficult to accurately characterize, although the following simple observation of non-target distributions can be made. Increased numbers of non-target parameters were detected in the following four monitoring wells:

- the nested well pair below the Boone-Nissan septic field (MW-11 and MW-12),
- the well located along the southern saddle (MW-9), and
- the low production well next to the disposal area access road (MW-7).

The detected non-target parameters were primarily BTEX components and other organic compounds commonly associated with automotive and other mechanical applications. As such, the detection of these compounds is not unanticipated.

Non-target parameter distribution trends will continue to be evaluated. *The detection of* these non-target compounds have not been *confirmed* as a result of *repeated* background analyses (Table 6A, Appendix I). The isolated detection of these non-target compounds in these wells is not indicative of a pervasive, persistent occurrence.

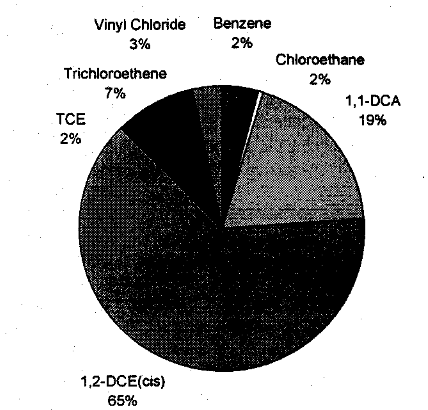
4.7 Organic Parameter Trends/Biotransformations

The organic parameter distributions presented in the previous section illustrate the two primary flow paths at the site and identify the most common parameters found within the respective bedrock aquifer mediums of the two primary flow paths. Pie distribution charts presented for each individual core assessment monitoring well are utilized in the following discussion to illustrate organic parameter distribution trends and potential biotransformation reactions occurring on-site.

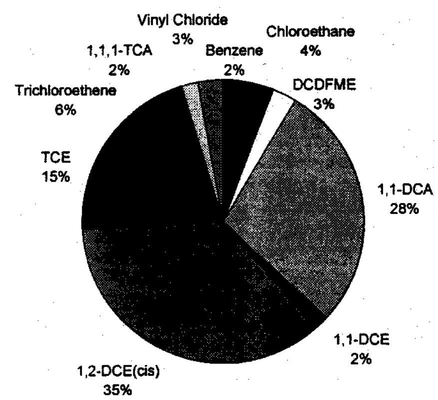
The pie charts display the percentage of specific organic target parameters detected in the individual assessment monitoring wells. Comparison of the pie charts reveal that the distribution of organic parameters can be separated into three primary areas with predominant organic parameters varying by location.

As shown below by the pie distribution charts for MW-6 and MW-8, the chlorinated ethenes (PCE, TCE, 1,2-DCE) predominate in the upper portion of the west drainage.

MW-6

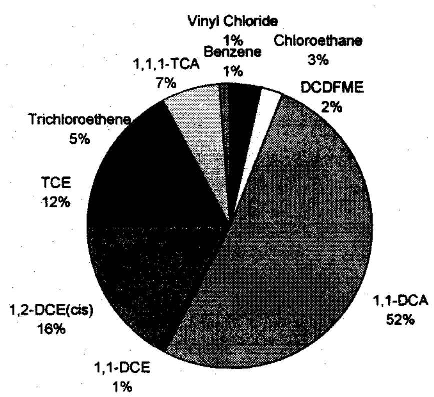


MW-8

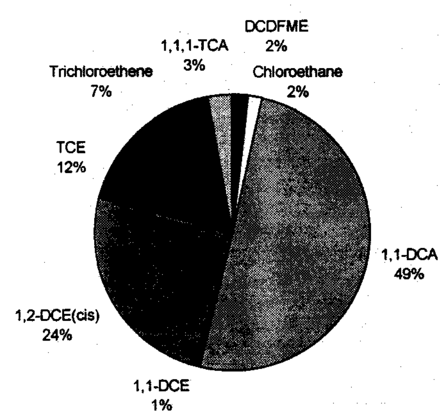


As shown below by the pie distribution charts for MW-3 and MW-17, 1,1-DCA is prevalent downgradient along the west drainage, although the ethenes continue to persist.

MW-3

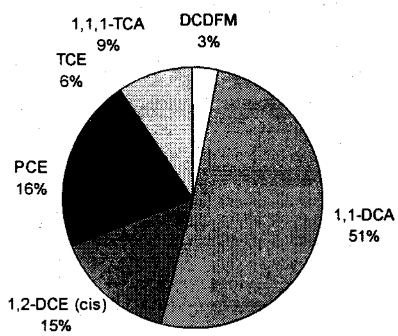


MW-17

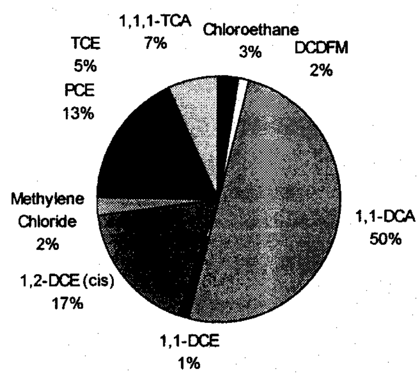


These organic parameter distribution trends are also reflected in the nested well pair further downgradient along the west drainage, as shown below by the pie distribution charts for MW-11 and MW-12.

MW-11

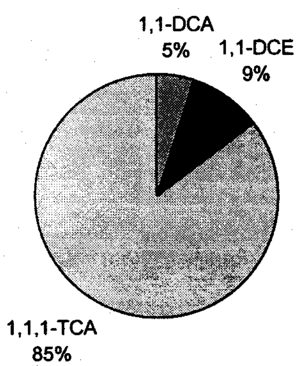


MW-12

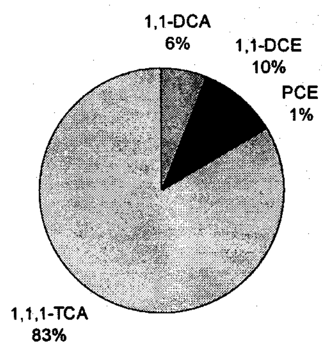


As shown below by the pie distribution charts for MW-2 and MW-10, in the north drainage the ethane's are more predominant (1,1,1-TCA and 1,1-DCA), with the exception of 1,1-DCE which is also found in the north drainage.

MW-2

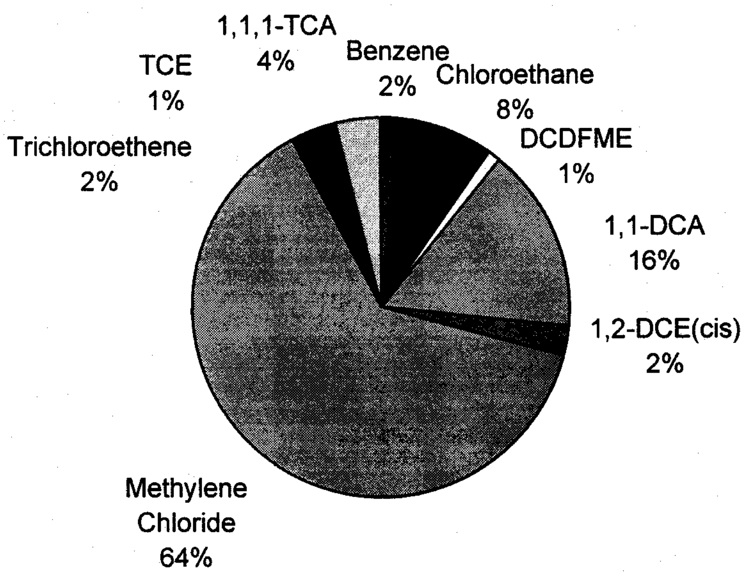


MW-10



Consistently elevated concentrations of Methylene Chloride contamination seems to be isolated to the southern saddle. As shown below by the pie distribution chart for MW-9, Methylene Chloride is also the predominant organic compound detected at this location.

MW-9



Based on the appearance of certain parameters in the west drainage, it would appear that PCE and/or TCE are undergoing some transformation reactions. PCE and TCE have a high degradation potential under anaerobic conditions. Two of the primary "daughter products" of this anaerobic degradation are cis-1,2-DCE and Vinyl Chloride. Both of these compounds are found in the west drainage. Due to increase microbial activity, an anaerobic zone most likely exists closer to the landfill, in the area surrounding MW-6 and MW-8, whereas a more aerobic zone may exist further downgradient towards MW-3 and MW-17.

Assuming these aerobic and anaerobic zones exist, biotransformations of the more highly chlorinated compounds (PCE and TCE) will occur near the landfill in the anaerobic zone. As daughter compounds are formed in this area, the sequential degradation rate of these new compounds will be much slower. As cis-1,2-DCE and

Vinyl Chloride enter the aerobic zone, however, degradation will be enhanced by the presence of oxygen. This trend is represented in the concentration distribution plots, as cis-1,2-DCE and Vinyl Chloride comprise the highest percentage of organic parameters found near the waste (i.e.: anaerobic area) and comprise lower percentages of organic parameters found more distant from the waste (i.e.: aerobic area).

Migration of the primary organic parameters found in the West Drainage Area (PCE, TCE, cis-1,2-DCE, and Vinyl Chloride) should favor the transport of cis-1,2-DCE and Vinyl Chloride, due to the higher solubilities and lower partition coefficients of these parameters. However, the concentration distributions indicate that the center of the PCE and TCE plumes have migrated further away from the landfill than cis-1,2-DCE and Vinyl Chloride. This suggests that cis-1,2-DCE and Vinyl Chloride are being mitigated within the west drainage. As previously discussed, this mitigation may be caused by the presence of an aerobic zone, located downgradient within the west drainage, where degradation of cis-1,2-DCE and Vinyl Chloride may be enhanced.

Elevated concentrations of 1,1,1-TCA and 1,1-DCE as well as 1,1-DCA occur in the north drainage. Under anaerobic conditions, 1,1,1-TCA is known to degrade abiotically to 1,1-DCE and biotically to 1,1-DCA. This is supported by numerous studies citing the elimination reaction undergone by 1,1,1-TCA to form 1,1-DCE under anaerobic conditions, which are most likely present close to the fill. A waste analysis by the NCDEHNR performed in 1988 which identified both 1,1,1-TCA and 1,1-DCE in a sample of solvent waste sludge known to be deposited in the landfill also suggests that 1,1-DCE may be associated with the same source as 1,1,1-TCA.. Both of these mechanisms are probably contributing to the levels of 1,1-DCE found in the north drainage.

1,1-DCA appears to be the most widespread contaminant at the site. Its persistence in both the north and west drainages could be associated with it presence as a source parameter at the site. However, 1,1-DCA is also a microbial degradation product of 1,1,1-TCA. If degradation of PCE/TCE is prevalent in the west drainage, it is possible that anaerobic microbial reduction of 1,1,1-TCA to 1,1-DCA will also be favored in this area. This would explain the appearance of 1,1-DCA in the west drainage area as a degradation by-product of 1,1,1-TCA. Very scarce amounts of 1,1,1-TCA have been found in the west drainage and this could be in part due to the rapid conversion of 1,1,1-TCA to 1,1-DCA.

The presence and persistence of 1,1-DCA in the west drainage can be contributed to reduced degradation rates of 1,1-DCA in an aerobic zone. 1,1-DCA is reported as a fairly recalcitrant compound, with a low degradation rate in an anaerobic zone and an even lower degradation rate in an aerobic zone. This supports the persistence of 1,1-DCA in the west drainage, where anaerobic zones may exist close to the waste area and aerobic zones may exist further downgradient.

Despite the correlations with analytical results described above, there is still not adequate evidence to prove or disprove the existence of these biotransformation reactions within the aquifer system. More data over *time* and data relating to redox conditions would assist to establish the criterion for an aerobic/anaerobic transforming system. Moreover, other subsurface factors may also limit degradation, such as nutrient limitations, substrate availability, toxicity, pH, etc. that would make the subsurface environment unfavorable for microbial growth.

4.8 Conclusions

4.8.1 Parameter Distribution

The analytical results obtained from the first semi-annual assessment monitoring event (also the first *annual comprehensive event*) are similar to the results obtained from the previous background events. The analytical results from these five assessment monitoring events continue to indicate that the detection of target parameters in the Watauga County Landfill monitoring network is primarily confined to those monitoring locations existing south of the proposed U.S. Route 421 Bypass (Figure 2; Appendix I).

As detailed in Section 2.3.1, the relocation of five (5) of the assessment monitoring wells (MW-12, MW-13, MW-14, MW-15, and MW-18), as originally proposed in the Assessment Plan (DAA, September 3, 1993), was necessary due to the proposed rerouting of U.S. Route 421. The construction right-of-way for the proposed bypass would have directly impacted the original locations for these five wells, likely requiring their premature abandonment. Four of these wells were relocated north (MW-13, MW-14, MW-15, and MW-18) and one well was relocated south (MW-12) of the proposed bypass.

The four background and first semi-annual analytical results indicate no elevated concentrations of target parameters in the four monitoring wells relocated north of the proposed bypass. Conversely, the recent analytical results reveal five target parameters detected above the method CRQL in MW-12, relocated south of the proposed bypass. The analytical results indicate the northern edge of the occurrence of assessment target parameters in the groundwater is located near or within the construction right-of-way for the proposed Route 421 bypass.

South of the proposed bypass, the detection of assessment target parameters was distributed between the southern saddle, located between the landfill and the Rocky Mountain Heights Subdivision, and the west and north drainages below the landfill.

In the west drainage, the detection of target parameters above groundwater standards was observed in both the soil and bedrock aquifer media, extending from the landfill to the proposed bypass. Organic analyses performed on the piezometer network on November 16-18, 1992, indicates the target parameters are confined to the trough of the west drainage. *Two* organic compounds were found above surface water standards at the surface water sampling location in the west drainage. The organic compounds and relative levels detected in the surface water sampling location in the west drainage are consistent with the those detected in adjacent groundwater monitoring wells, although at lower concentrations, and indicate that organic impacts to surface water are entirely due to local groundwater discharge at this location..

In the north drainage, the detection of target parameters above groundwater standards was confined to the bedrock aquifer medium. The levels of the target parameters detected in the two monitoring wells accessing the bedrock aquifer medium indicate the parameters have preferentially migrated to deeper fracture zones within the bedrock.

Several organic compounds detected in the monitoring well located along the saddle between the landfill and the Rocky Mountain Heights subdivision were observed at markedly different concentrations than the levels of the organic compounds detected in the remainder of the monitoring well network. In addition, several different organic compounds were detected along the saddle between the landfill and the Rocky Mountain Heights subdivision that were not detected in the remainder of the monitoring well network.

The distribution trends of the analytical results obtained from background assessment monitoring events indicates that the aquifer system may be attaining steady-state conditions. Target parameter concentration and distribution trends indicate steady state conditions are predominant across the site. The steady state conditions observed thus far suggest no more contaminants are entering the groundwater from the waste disposal area than are naturally attenuating as the groundwater approaches the Route 421 bypass. Although the current assessment background monitoring data does not allow an adequate temporal range to provide conclusive evidence of steady state conditions, additional assessment monitoring in the coming years will provide the temporal data to properly assess contaminant transportation, migration, and fate trends.

The analytical results indicate that the concentrations of target organic parameters within the groundwater appear to be naturally attenuating or diminishing attenuating as the groundwater approaches the Route 421 bypass. Migration of detectable concentrations of the target parameters beyond the current boundary is not anticipated. Several factors may be contributing to the attenuation, although the predominant influence is likely dilution. As the organic parameters enter increasingly larger aquifer domains with expanding recharge extent, organic concentrations naturally attenuate or diminish. Ongoing assessment monitoring will continue to evaluate the transport, migration, and fate of the organic parameters and evaluate aquifer equilibrium conditions

4.8.2 Target Parameter Summary

The detection of five target parameters, PCE, TCE, cis-1,2-DCE, Dichlorodifluoromethane, and Chloroethane, was primarily reported within the west drainage and southern saddle.

The detection of 1,1,1-TCA and 1,1-DCE was observed in both the west and the north drainages, although these parameters were observed at significantly higher elevated levels in the north drainage, particularly at the deep bedrock well MW-2. The detection of 1,1,1-TCA was also observed along the southern saddle.

The detection of 1,1-DCA was observed at elevated concentrations in more monitoring wells throughout the site than any other target parameter, although 1,1-DCA was observed at the highest concentrations in the west drainage.

Methylene Chloride was persistently detected at significantly higher concentrations in one well, MW-9, located along the southern saddle between the landfill and the Rocky Mountain Heights subdivision. Lower levels of Methylene Chloride were irregularly detected in eight other monitoring wells.

Benzene was detected in ten monitoring wells. Higher concentrations of Benzene are preferentially distributed adjacent and west of the disposal area. Lower estimated concentrations were persistently found distributed further downgradient within the west drainage and in MW-9, located along the southern saddle between the landfill and the Rocky Mountain Heights subdivision.

Vinyl Chloride was detected in four monitoring wells, all preferentially centrally located in the west drainage, adjacent to the waste disposal area.

Trans-1,3-Dichloropropene was not detected in any monitoring well on any of the five assessment sampling events.

4.8.3 Continuing Investigations

Ongoing assessment monitoring will continue to evaluate the transport, migration, and fate of the organic parameters and evaluate aquifer equilibrium conditions. Continued modeling of the site will utilize Draper Aden Environmental Modeling's (DAEM) services to assist in evaluating aquifer equilibrium conditions. DAEM produces state-of-the-art numerical models for fate and transport of contaminants that will be applied to optimize site characterization and minimize the cost of data collection efforts involved with evaluating aquifer equilibrium conditions and assessing subsurface conditions.

Crude modelling has been conducted. However, more data is needed to accurately evaluate equilibrium conditions

As a result of the four background and first semi-annual background sampling events, three areas are identified as not fully characterized by the existing monitoring network. As described below, these three areas will continue to be evaluated during ongoing groundwater investigations.

West Drainage

As detailed in the following section on the site geology and hydrogeology, the west drainage adjacent to the landfill trends parallel to the orientation of two lineament sets observed at the site. Upper reaches of the west drainage trend parallel to mineral layering, lineation, and foliation in the host bedrock as well as parallel to the general northwest trending contact between the amphibolite/hornblende gneiss-mica schist and gneiss assemblages and the "mixed rocks" assemblage (N55°W). Upon reaching an area where the amphibolite/hornblende gneiss is not stratigraphically overlain by the mica schist and gneiss (inferred from drilling of MW-18 as well as the distribution of residual soil distributions depicted on the Watauga County Soil Survey), the drainage trends N10°E, parallel to bedrock fracture and joint lineations.

The original proposed locations for MW-13 and MW-18 were at the junction of the N55°W and N10°E lineament sets. MW-13 and MW-18 were relocated along the N10°E lineament set to account for the flow direction of the surface water drainage. Trace level detections observed in the BREMCO potable well (Potable Well Analysis Summary Table, Appendix II) indicate the possibility that deeper groundwater flow within the bedrock may follow the N55°W lineament set. An additional assessment monitoring well is proposed in the area between the proposed bypass and the BREMCO potable well. This area will also continue to be evaluated during ongoing groundwater investigations with continued potable well sampling and analysis.

An additional surface water sampling location is also proposed below the existing surface water sampling location S-4. This additional surface water sampling location will provide information necessary to assess the influence of surface water impacts observed at S-4 further downgradient along this west drainage.

North Drainage

Background analytical results indicate elevated levels above groundwater standards for the target parameters in the northern drainage below the landfill at the deep bedrock monitoring well, MW-2. Downgradient of this point the bedrock aquifer system enters the central watershed of Rocky Branch and is likely significantly diluted. Groundwater entering the Rocky Branch watershed from the northern drainage may be exhibiting lateral stratification. Rather than continuing to follow the northern drainage orientation, groundwater may flow N55°W, parallel to Rocky Branch, before reaching the apex of the watershed. Therefore, the area between the nested well pair, MW-14 and MW-15, and the Chevrolet Dealership will continue to be evaluated during ongoing groundwater

deeper flow (where contaminants likely reside) are discrete fractures (needle in haystack) investigations. The absence of target organic parameters at the Chevrolet Dealership's potable well suggests non-impact at the dealership's well location.

Southern Saddle

The analytical results obtained from the monitoring well installed along the saddle between the landfill and the Rocky Mountain Heights Subdivision (MW-9) indicate the organic parameters observed in Carroll residence potable well are not confined to the Carroll property. To examine potential flow pathways not currently investigated by the Residential and Business potable well sampling program (described in the Assessment Plan, Activity Report, Third Quarter Background Monitoring Event Results Report, 1st Semi-Annual Monitoring Event Results Report, and summarized herein in Section V and Appendix II), the area directly downgradient and south of the Carroll property will be evaluated for additional groundwater investigations. A residential well does not currently exist immediately downgradient of the Carroll property. To further investigate the parameter distributions across the saddle from the Carroll property, the area between the landfill and MW-9 will also be evaluated for additional groundwater investigations.

The primary design objective of the monitoring well network is to determine the horizontal and vertical extent of groundwater contamination at and in the vicinity of the Watauga County Landfill boundary. As described above, three areas are currently being evaluated for additions to the existing monitoring network (i.e. west drainage, north drainage, and southern saddle). At the present, installation of additional monitoring wells in these areas is only proposed for the west drainage. These areas will continue to be evaluated during ongoing investigations. The results of the potable well sampling program will continue to assist ongoing groundwater investigations within areas not fully characterized by the existing monitoring well network and within which the source or sources of contamination are still under investigation.

4.8.4 Second Semi-annual Assessment Background Monitoring Event

The second semi-annual assessment monitoring event (sixth assessment event) is tentatively scheduled to be performed by Draper Aden Associates in January, 1996. As indicated in the Assessment Monitoring schedule (Table 1, Appendix I), all assessment monitoring wells will be analyzed utilizing CLP analytical methods for the second semi-annual assessment monitoring event. Surface water monitoring points will also be analyzed using CLP analytical methods.

As discussed in previous sections 4.5 and 4.6, revisions to the target inorganic parameter list involve adding four metal parameters; i.e.: Chromium, Cobalt, Nickel, and Vanadium, and deleting two other metal parameters; i.e.: Cadmium and Mercury. Chromium, Cobalt, Nickel, and Vanadium were observed in three (3) or more core monitoring wells, although also at levels far below EPA MCL and North Carolina groundwater standards, as a result of the first comprehensive annual EPA Appendix II List assessment sampling event. The presence of Cadmium and Mercury in the groundwater at the site is not supported by the analytical results of all four assessment background or the first semi-annual monitoring events.

As also discussed in Sections 4.5 an 4.6, revisions to the target organic parameter list involve deleting trans-1,3-Dichloropropene. The analytical results of the four background monitoring events and the first annual EPA Appendix II list sampling event (utilizing LLRA analytical methods) confirmed the absence of trans-1,3-Dichloropropene in the groundwater and surface waters at the site. Thus, per the decision criteria outlined in the Assessment Plan, trans-1,3-Dichloropropene will be removed from the Target Parameter List. No additions to the organic target parameter list are proposed at this time.

Revisions to the network of core and boundary assessment wells for the first semi-annual assessment monitoring event involved in the upgrading of monitoring well MW-7 to "core" status and the downgrading of MW-4 to "boundary" status. Due to the repeated detection of low levels of 1,1,1-TCA observed in the boundary well MW-15 during the past five assessment monitoring events, MW-15 will also be upgraded to core status for the second semi-annual assessment monitoring event.

As discussed in the previous Section 4.8.3, it is proposed that an additional assessment monitoring well be installed in the west drainage between the proposed bypass and the BREMCO potable well and that an additional surface water sampling location be monitored below the existing surface water sampling location S-4.

It is also proposed that the non-impacted boundary wells (i.e.: MW-4, MW-5, MW-13, MW-14, MW-16, and MW-18) be withdrawn from the routine compliance monitoring program at this time. The eleven core assessment monitoring wells will continue to be monitored on a semi-annual basis. The non-impacted boundary wells will remain operational to allow for future monitoring based on temporal contaminant distribution trends observed after each semi-annual event .

4.8.5 Summary of Proposed Assessment Monitoring Program Revisions

In summary, revisions to the assessment target parameter list involve the following:

- addition of four metal parameters;
  Chromium, Cobalt, Nickel, and Vanadium, and
- deleting of two metal and one organic parameter;
  Cadmium, Mercury and trans-1,3-Dichloropropene.

Revisions to the network of core and boundary wells involve the following:

- addition of one monitoring well and one surface water sampling location further downgradient along the west drainage,
- upgrading of boundary monitoring well MW-15 to core status, and
- withdrawal of the non-impacted boundary monitoring wells (i.e.: MW-4, MW-5, MW-13, MW-14, MW-16, and MW-18) from the routine compliance monitoring program.

Upon the approval of the NCDEHNR, the revisions outlined above will be implemented with the second semi-annual assessment monitoring event (sixth assessment event), tentatively scheduled to be performed by Draper Aden Associates in January, 1996.

V. POTABLE WELL SAMPLING PROGRAM

5.1 Introduction

The initial domestic and commercial use potable water well sampling event was developed and conducted by Draper Aden Associates on March 5, 1993 at the direction of Watauga County and approval of State officials to protect public health and welfare. The ongoing potable water well sampling, analysis, and evaluation program is currently being jointly conducted by the Appalachian District Health Department (ADHD), and the North Carolina State Laboratory of Public Health.

The objective of the potable well sampling and analysis program is to investigate, evaluate and track the potential influence and associated risks of the impacted groundwater on neighboring groundwater resources. Potable well water samples collected by the ADHD are analyzed for volatile organic compounds by the State Laboratory utilizing EPA Method 502.2. Potable water well locations with accompanying sampled well reference number can be found on the Groundwater and Surface Water Monitoring Program Site Map (Figure 2). A summary of the analytical results of the potable well testing program collected to date are presented in Appendix II.

The analytical results of the domestic and commercial use potable water well sampling and analysis program indicate that two (2) of the thirty eight (38) sampled potable wells are significantly impacted by volatile organic compounds. These two (2) significant impacted wells are the Carroll residence (well reference no. 12) and the Nissan-Mazda Dealership well (well reference no. 4).

At this time the cause or source of the organics detected in the potable well sampling program cannot be determined. It should be noted that many of the detected compounds have not been detected in the landfill monitoring well network. Eight (8) of twenty-one (21) compounds detected in the Carroll residence potable well, as a result of three sampling events, have not been detected in the landfill monitoring well network. Three (3) of fifteen (15) compounds detected in the Nissan-Mazda Dealership potable well, as a result of two sampling events, have not been detected in the landfill monitoring well network. The presence of these nonlandfill related compounds in groundwater beneath these sites tends to indicate potential impacts resulting from activities specifically undertaken on these sites and/or immediately around the private well heads and/or components of the well systems.

The North Carolina State Division of Epidemiology's review of the analytical results from all the potable well sampling conducted in the past year indicates that the sampled well waters are acceptable for all uses due to either non-detection or only trace detection of organic analytes. The two (2) potable water wells previously identified as significantly impacted (i.e. Carroll residence and the Nissan-Mazda Dealership) have been replaced by alternative water sources and have not been resampled during the past year.

5.2 Analysis Results Summary

Presentations of individual potable well analytical results can be found in Section 2.10 of the Assessment Plan (dated Sept. 3, 1993), Section III of the Activity Report (dated June 29, 1994), Section VII of the Third Quarter Background Monitoring Event Report (dated August 31, 1995), and Section VII of the First Semi-Annual Monitoring Event Report (dated January, 1996). The summary discussion below concentrates on those few wells that have previously shown trace level detections of organics similar to those detected in the landfill groundwater monitoring network. As shown, the duplicate sampling indicates the organics detected are a persistent occurrence.

Blue Ridge Electric Membership Company, BREMCO (well reference no. 5)

Six (6) chlorinated volatile organic solvent compounds were detected in the recent October 24, 1995 sampling of the BREMCO potable well (1,1-Dichloroethane, 1-1-Dichloroethene, Cis-1,2-Dichloroethene, 1,1,1,-Trichloroethane, Trichloroethene, and Tetrachloroethene). The only compounds detected at quantifiable levels were 1,1-Dichloroethane (1,1-DCA), which was detected just above the detection limit of 1 ppb at 1.8 ppb, and 1,1-Dichloroethene (1,1-DCE), which was also detected just above the detection limit of 1 ppb at 1.7 ppb. No EPA Maximum Contaminant Level exists for 1,1-DCA. The EPA MCL for 1,1-DCE is 7 ppb. The other detected organic compounds were observed at unquantifiable levels below 1 ppb.

The same six (6) chlorinated volatile organic solvent compounds detected as a result of the recent sampling event have also been detected in previous sampling events conducted on the BREMCO potable well, and all of these six (6) compounds have been detected in the past three (3) sampling events. Three of these compounds (1,1-Dichloroethane, 1,1,1-Trichloroethane, and Trichloroethene) have been detected in all five previous sampling events.

Ward Residence (well reference no. 24)

The recent October 24, 1995 resampling and analysis of the Ward residence potable well detected trace levels of Chloroform and Tetrachloroethene, and unquantifiable levels below 1 ppb of 1,1-Dichloroethane.

Five sampling events had been conducted on the Ward residence potable well prior to this recent sampling,. The combined analyses from the previous sampling events conducted on the Ward residence potable well had detected trace and/or unquantifiable levels below 1 ppb of five (5) chlorinated organic compounds (Carbon Tetrachloride, 1,1-Dichloroethane, 1,1,1-Trichloroethane, Trichloroethene, and Tetrachloroethene).

The initial Ward residence sampling event also detected Methylene Chloride at 3.2 ppb. The next five consecutive sampling events at the Ward residence resulted in the nondetection of Methylene Chloride. Methylene Chloride is also a known laboratory contaminant.

The third Ward residence sampling event also detected trace levels of chloroform. The other five sampling events conducted at the Ward residence had resulted in the nondetection of chloroform. Chloroform is a common transformation product result from the chlorination of well systems.

The fourth Ward residence sampling event resulted in no detected volatile organic compounds.

<u>Shared Well #2 (well reference no. 14)</u>

Shared well #2 serves four residences. Shared well #2 was originally sampled from the Cone residence on March 18, 1993. Resampling of shared well #2 conducted on March 30, 1994 and on January 12, 1995, and the recent October 24, 1995 resampling, was performed on the adjacent Edwards residence.

The initial March 18, 1993 sampling detected only low levels of 1,4-Dichlorobenzene, which is a compound that has not been detected in the landfill monitoring well network.

The second March 30, 1994 sampling detected trace levels of Chloroform, which again is a common transformation product resulting from the chlorination of well systems, and also detected two (2) common chlorinated organic compounds (1,1-Dichloroethene and 1,1,1-Trichloroethane) at unquantifiable levels below 1 ppb.

The third January 12, 1995 sampling only detected 1,1-Dichloroethene at unquantifiable levels below 1 ppb.

Shared well #2 was recently drilled deeper in order to provide needed water production. Resampling was performed to investigate the effect of drilling the well deeper on the concentrations of organic compounds found in this potable well.

The recent fourth resampling performed on October 24, 1995 detected 1,1-Dichloroethane (not 1,1-Dichloroethene) at unquantifiable levels below 1 ppb, trace levels of Tetrachloroethene and 1,1,1-Trichloroethane, and Chloroform at 9 ppb. Chloroform is likely a transformation product resulting from the recent chlorination of the well system. A variety of additional compounds that due not appear related to the organic constituents found in the landfill's monitoring well network were also detected. These compounds include the following: Bromodichloromethane, Dibromochloromethane, 2-Chlorotoluene, 4-Chlorotoluene, Methyl Ethyl Ketone, and Tetrahydrofuran. The presence of these compounds are likely the result of the recent overdrilling of the well bore.

5.3 Recommendations

In summary, the North Carolina State Division of Epidemiology's review of the analytical results from all the potable wells (excluding the two significantly impacted wells that have been replaced with public water) indicate that the sampled well waters are acceptable for all uses due to either nondetection or very low level detection of the organic analytes. At this time the cause or source of the low level detected organics can not be determined.

Draper Aden Associates recommends that potable water well sampling program continue to concentrate on sampling those few wells that have previously shown trace level detections of organics similar to those detected in the landfill groundwater monitoring well network. Continued sampling will indicate whether the organics detected are a persistent occurrence and if so, whether concentration levels of the detected organics are increasing. Although alternate water supplies are currently provided, DAA also recommends continued periodic sampling of the two (2) significantly impacted wells, the Nissan-Mazda dealership well (well reference no. 4) and the Carroll residence well (well reference no 12) will also be periodically sampled.

Handled by Applac. District Health Dept. (ADHD)

- ADHD said they would not be able to shoulder this responsibility as proposed by Boone

- J. Smith will call John Alley (ADHD) to discuss a new proposal w/ him.

core Potable wells:
5, 24, 14,

VI. REMEDIAL ACTION ALTERNATIVES

A presentation and evaluation of remedial action objectives and remedial action alternatives follows. These remedial action objectives and remedial action alternatives are based on the assessment site investigation, remedial goals, previous experience at municipal landfill sites, and professional engineering judgment. In response to the remedial site characterization discussed earlier in this report, groundwater containment will be the primary focus of the evaluation of remedial action alternatives. These remedial action objectives and alternatives will continue to be evaluated with respect to information collected during ongoing assessment monitoring.

Remedial Cap

A remedial cap, supplemented by additional remedial responses, is proposed as an immediate remedial action for NCDEHNR review and approval. This proposed remedial action focuses on source containment (i.e. containment of the waste disposal area), as established by the EPA's presumptive remedy directive for municipal landfill sites (EPA 540-F-93-035, September 1993), contained herein Appendix III. EPA's presumptive remedy directive is consistent with Section 300.430(a)(iii)9(B) of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) which contains the assumption that engineering controls, such as containment, will be used for situations were treatment is impracticable. The EPA generally considers containment to be the appropriate response action, or "presumptive remedy," for the source areas of municipal landfill sites.

The remedial cap will assist in containing the source by reducing the amount of water that is infiltrating into the disposal area, thereby reducing the driving force mobilizing the source. Modeling of infiltration rates utilizing the EPA HELP Model, Version 3, indicates the geotextile cap design, as detailed in Section VII of this RIA report, will prevent approximately 12 million gallons of water per year from infiltrating into the approximately 20 acre disposal area. Reducing 12 million gallons from entering the disposal area will assist greatly in containing the source.

The following discussion regarding potential remedial action alternatives explains why treatment of groundwater at the Watauga County Landfill site is impractical. Ongoing assessment monitoring will continue to track the horizontal and vertical extent of contamination and characterize the transport, migration, and fate of contamination in the groundwater. The ongoing potable well investigation into potential groundwater contamination migration pathways surrounding the site will continue.

Continued modeling of the site will utilize Draper Aden Environmental Modeling's (DAEM) services to optimize site characterization, further investigate fate and transport, and assist risk assessment and management efforts.

6.1 Remedial Action Objectives and Goals

Remedial response objectives are site-specific. Initial cleanup objectives are established on the basis of the nature and extent of the contamination, the resources that are currently and potentially threatened, and the potential for human and environmental exposure. Listed below are typical remedial action objectives for impacted groundwater at municipal landfill sites.

- Prevent exposure to contaminated ground water;
  - Provide an alternative water supply for the population that has existing wells impacted,
  - Establish institutional controls to restrict access to impacted groundwater.

- Protect uncontaminated ground and surface water for current and future use;
  - Prevent impact to existing wells that could be affected by flow and transport of impacted groundwater to adjacent groundwater,
  - Minimize migration of contaminants within the ground and surface water,
  - Minimize migration of contaminants to adjacent ground and surface water.

- Restore impacted ground water for future use;
  - Reduce concentrations within the area of influence to levels that are safe for drinking.

- Protect environmental receptors;
  - Reduce concentrations to levels that are safe for biological receptors that may be affected at the ground-water discharge point.

While this list covers many of the situations encountered at municipal landfill sites, other remedial action objectives may be appropriate because of site-specific conditions. The specificity of these objectives may vary depending on the availability and quality of site information, site conditions, and the complexity of the site. (EPA/540/G-88/003 December, 1988). The following discussion evaluates potential general response actions in regard to the response objectives described above and their applicability to the site.

6.2 Remedial Action Alternatives

The objective of the EPA's presumptive remedies initiative is to use the past experience of the Superfund Program to streamline and speed up selection and implementation of cleanup actions. An important step in this process is to develop and implement prompt, effective, site-warranted solutions. As detailed in the following section, the remedial cap is proposed as a source containment component of the comprehensive remedial response.

6.2.1 Remedial Alternatives Evaluation

Other components that have been considered as potential remedial alternatives include extraction, plume containment, groundwater treatment, and institutional controls. The range of remedial technologies and remedial alternatives as presented in the following discussion can be thoroughly evaluated in a phased approach for the general response action. Comprehensive remedial responses can be developed from combinations of these various process options.

Appendix A of the EPA Presumptive Remedy Directive (contained herein Appendix III) states: "...analysis that EPA conducted of feasibility study (FS) and Record of Decision (ROD) data from CERCLA municipal landfill sites led to the establishment of containment as the presumptive remedy for these sites. The objective of the study was to identify those technologies that are consistently included in the remedies selected, those that are consistently screened out, and to identify the basis for their elimination. Results of this analysis support the decision to eliminate the initial technology identification and screening steps on a site-specific basis for this site type. The technical review found that certain technologies are appropriately screened out based on effectiveness, implementability, or excessive costs".

Screening criteria that was used by the EPA to evaluate the range of alternatives for the FS and RODs are detailed as follows:

- *Effectiveness* in reducing contaminant levels in the plume, attaining ARARs or other health-based levels, and protecting human health and the environment
- *Implementability* with respect to technical and administrative feasibility of the alternatives and the availability of needed technologies and services
- A general cost analysis to identify alternatives that are significantly more costly than other alternatives that achieve the same level of contaminant reduction

Detailed descriptions of each of the above criteria are reported in the EPA RI/FS Guidance Document (EPA/540/G-89/004).

The site characterization presented in the previous sections of this report identified the physical conditions of the site, including potential sources, extent and associated concentrations of target parameters detected in the groundwater, as well as related aquifer characteristics.

As discussed in the previous sections of this report, the contaminants have migrated to a variety of different aquifer mediums situated beneath different topographic areas. The effectiveness of remediation techniques are highly dependent on these widely variable site specific characteristics. As detailed below, although one remediation method may be feasible at one location, site-wide application of one individual remediation method would not likely be effective.

The ability and rate to which an aquifer can be restored is affected by contaminant-soil interactions, the nature of the contaminants, and the physical conditions of the site and contaminant distributions. The size and associated contaminant concentrations of the contaminant domain and the transmissivity and other associated characteristics of the aquifer also will directly affect the restoration time frame. For example, leaching of contaminants from large areas contaminated at low concentrations or from non-homogeneous fills as appears to be occurring at Watauga County Landfill may continue to affect the ground water and should be accounted for to the extent possible in estimating the restoration time frame. Estimations for the restoration capabilities and time frames will likely be underestimated if site complexities are not fully appreciated.

When flow patterns are complex and the hydrogeologic system is difficult to characterize, the potential for unanticipated migration pathways to develop increases, which may reduce the effectiveness of the remedial action. Although remedial actions should be designed to prevent, as quickly as possible and to the extent practicable, further spread of contaminants in these complex systems, some hydrogeologic systems, such as areas with fractured bedrock like that existing at the Watauga County Landfill, make invasive remediation of groundwater impracticable.

As discussed previously, target parameter concentration and distribution trends observed during background assessment monitoring indicate that steady state conditions are predominant across the site. The steady state conditions observed thus far suggest that no more contaminants are entering the groundwater from the waste disposal area than are naturally attenuating as the groundwater approaches the Route 421 bypass. Migration of detectable concentrations of the target parameters beyond the current boundary is not anticipated. Although the current assessment background monitoring data does not allow an adequate range of time to provide conclusive evidence of steady state conditions, additional assessment monitoring in the coming years will provide the temporal data to properly assess contaminant transportation, migration, and fate trends. The confirmed presence of steady state conditions will allow for the selection of site-warranted remedial solutions.

6.2.2 Remedial Alternative Options

The following discussion elaborates on potential general response components in regard to applicability to the Watauga County Landfill site.

<u>Source Containment</u>

The remedial cap proposed as an immediate remedial action focuses on source containment. **EPA analysis of FS and ROD data from CERCLA municipal landfill sites (contained herein Appendix III) indicates that a multi-layer cap passed screening for a total of 25 out 28 facilities.**

Modeling of infiltration rates utilizing the EPA Help Model, Version 3, indicates that the interim cap currently designed for the landfill cover will allow 590,000 gallons/per acre/per year to infiltrate into the disposal area. Various designs of the remedial cap will prevent approximately 201,000 (Subtitle D cap) to 587,600 (membrane cap) gallons/per acre/per year from infiltrating into the disposal area. The geotextile cap design, as detailed in Section VII of this RIA report, will prevent approximately 12 million gallons of water per year from infiltrating into the disposal area. By preventing this water from infiltrating into the disposal area, the remedial cap will greatly assist source containment efforts.

The remedial cap, as proposed, will consist of the following multiple layers from the top down:

6" vegetative layer
18" cushion layer
Drainage layer
40 mil LLDPE
12" bedding layer (compacted)
12" intermediate cover

The drainage layer can act as both a protective cover for the membrane and as the drainage medium. With this type of cap, infiltration will be reduced from 590,000 gal/acre/year (current cover) to 2,400 - 80,000 gal/acre/year depending on the drainage medium (geonet or geotextile, respectively).

The infiltration rates were modeled using EPA HELP Version 3.0 with the following assumptions:

Rainfall data	**Greensboro**
Slope	5%
Slope length	200 ft.
Soil Type	Sandy Silt (Default No. 7)
Total Porosity	Default
Field Capacity	Default
Wilting Point	Default
Hydraulic Conductivities	
Cushion	5x10-4 cm/sec
Drainage (Geonet)	10 cm/sec
Drainage (Geotextile)	2.5 x 10-1 cm/sec
Membrane	Default
Bedding	5x10-4 cm/sec
Stands of Grass	Fair (No. 3)
Fraction of Area Allowing Runoff	100%
FML - Pinhole Density	1/acre
Defect Density	3/acre
Placement Quality	Good (No. 3)

The modeling of the membrane compares well with similar modeling performed by NCDEHNR as published in the document entitled, "Analysis of Landfill Closure Cap Systems and Associated Costs", dated September, 1995 (Draft). Draper Aden Associates' modeling identified an infiltration rate of 2,400 gal/acre/year for this cap membrane utilizing a geonet drainage The NCDEHNR, which utilized similar parameters, identified an infiltration rate of 1,571 gal/acre/year.

Further discussion regarding the remedial cap is provided in the following Section VII.

Natural Attenuation with Monitoring and Institutional Controls

Natural attenuation generally is a long-term response action that relies on the groundwater's natural ability to lower contaminant concentration through physical, chemical, and biological processes until cleanup levels are met. Natural attenuation is generally recommended when invasive, direct restoration is not practicable, cost-effective, or warranted because of site-specific situations. A natural attenuation response action generally includes monitoring to track the direction and rate of movement of the contaminants, as well as responsibility for maintaining effective, reliable institutional controls to prevent use of the contaminated groundwater. This category of response action includes two distinct alternatives: (1) a natural attenuation alternative that includes monitoring and institutional controls that should be developed in many cases as a point of comparison; and (2) wellhead treatment or provision of an alternate water supply with institutional controls.

This corrective response action is warranted when it is not practicable or feasible to fully restore groundwater. The widespread occurrence, physical/chemical interactions and other contaminant-related factors, as well as hydrogeological constraints present at the site limit the effectiveness of invasive, direct restoration. Natural attenuation and institutional controls (i.e. public water) may be the only feasible remedies for these sites. As previously discussed, the steady state conditions observed thus far suggest that no more contaminants are entering the groundwater from the waste disposal area than are naturally attenuating as the groundwater approaches the Route 421 bypass. Migration of detectable concentrations of the target parameters beyond the current boundary is not anticipated.

Public water lines from the Town of Boone are currently scheduled to be extended along Route 421, directly northwest of the site, in the spring of 1996 . Engineering plans for installing the public water system along Route 421 are currently being reviewed by NCDEHNR. Upon approval, construction and installation of the public water lines will then be bid along with installation of the sewer lines. The presence of this reliable public potable water supply will significantly reduce potential impacts to human health.

EPA guidance recommends that for sites at which groundwater users are currently or potentially affected by the continued migration of contaminants before remedial measures are likely to be effective, the feasibility of providing an alternate water supply during the remedial action and the characteristics of any potential alternate water sources should be evaluated (EPA/540/G-88/033 December, 1988). The following issues should be addressed:

- The time and cost required to develop an alternate water supply
- The quality of the alternate water supply
- The reliability of the alternate water supply, particularly in terms of susceptibility to contamination
- The sustainable quantity, or safe yield, of the water supply, considering the water use demands of those current users affected by the site, any current or potential competing demands, as well as any water rights issues

The hydrogeological constraints posed by contaminant migration into fractured bedrock present at the site limit the effectiveness of active restoration since contaminants have likely migrated into formations from which they cannot easily be removed. Although limited contaminant reduction can usually be achieved, complete restoration to health-based levels is not feasible. Contaminant-related factors include situations where the nature of the contaminant makes restoration difficult. For example, when DNAPL compounds present at the site migrate to groundwater, they frequently sink to the less permeable material at the base of the aquifer, accumulating in isolated areas above the less permeable material. Generally, these contaminants can only be removed by extraction directly at the points of accumulation, which often cannot be identified practicably.

Site-specific contaminant and aquifer media related difficulties encountered with other various response alternatives are detailed below.

Plume Containment or Gradient Control

Plume containment refers to minimizing the spread of a plume through hydraulic gradient control, which can be either by using pumping wells, French drains, etc. or *by capping* or using a slurry wall, etc. Hydraulic gradient controls rely on the prevention of exposure for the protection of human health. Slow contaminant removal (for gradient control systems) or natural attenuation may gradually achieve cleanup levels within the contained area.

Containment of the existing plume through pumping wells, French drains, etc. is not technically feasible due to the variety and extent of the aquifer media affected. The steep topography of the site is reflected in steep potentiometric gradients occurring throughout the site, including upgradient recharge zones (as presented herein Section 2.4.2.4). Gradient controls would be very difficult to realize due to the problems inherent in overcoming these steep gradients. Gradient controls are also undesirable due to unknown impacts that can occur as a result of upsetting the equilibrium of the aquifer system. Contaminants residing in dead zones of the aquifer system can be released due to gradient changes, resulting in impacts to portions of the aquifer not currently affected.

Containment utilizing slurry walls would be hindered by the depth and associated aquifer media encountered across the site (as presented herein Section 2.4.2.1). A slurry wall could only be feasibly utilized within the soil aquifer medium and the association of the soil aquifer medium with the bedrock aquifer medium would severely reduce the effectiveness of the remedial application of the slurry wall.

Extraction and Treatment

An extraction system can be used to remove contaminated groundwater, followed by treatment, if required, and discharge or reinjection back into the aquifer. Extraction can be achieved by using pumping wells, French drains, or trenches. Pumping may be continuous or pulsed to remove contaminants after they have been given time to desorb from the aquifer material and equilibrate with groundwater. Treatment may involve air-stripping, carbon absorption, and biological treatment, depending on the physical/chemical properties of the contaminants.

The site specific hydrological constraints posed by contaminant migration into the fractured bedrock present beneath the site limit the effectiveness of site-wide active restoration by pump and treat methods, since contaminants can migrate into formations from which they cannot be effectively removed (see Section 2.4.2). Although some level of contaminant removal by pump and treat methods can usually be achieved, complete removal and treatment of contaminated groundwater is not feasible due the lingering effects of residual contaminants both absorbed to the aquifer medium and remaining in dead zones of the fracture system.

Biorestoration

Biorestoration relies on microorganisms to transform hazardous compounds into innocuous materials. Almost all organic compounds and some inorganic compounds can be degraded biologically if given the proper physical and chemical conditions and sufficient time. Some organic compounds readily biodegrade, while other molecules degrade at a much slower rate. Some organic compounds are toxic to microorganisms or inhibit their activity. In some cases, such as with the degradation of trichloroethylene to vinyl chloride, the by-products are more toxic than the parent compound.

Biorestoration is a passive process that occurs naturally in many aquifer systems, whether anaerobic or aerobic. Although attempts can be made to augment the biorestoration process by supplying nutrients and/or microorganisms to the aquifer systems, often biorestoration processes are already in place. Distinct biorestoration mechanisms may be active within different aquifer mediums as well as within different zones of the same aquifer medium.

The effectiveness of various bioremediation techniques are highly dependent on both site specific aquifer medium characteristics as well as the composition of compounds found at the site. Although one bioremediation method may be feasible at one location, site-wide application of one individual remediation method would not likely be effective. The variety of organic compounds found at the site also would limit the applicability and effectiveness of various bioremediation techniques. Individual microorganisms may remediate some organic compounds, while some organic compounds may be toxic to the same microorganisms. No microorganism would likely be effective in remediating all the organic compounds.

EPA analysis of FS and ROD data from CERCLA municipal landfill sites (contained herein Appendix III) indicates that both in-situ and ex-situ bioremediation methods were screened out of consideration for a total of 24 out of 25 facilities.

Soil Flushing

Soil flushing refers to applying a liquid flushing agent to contaminated soil to physically or chemically remove contaminants absorbed to the aquifer medium. As the term "soil flushing" implies, this remediation method only applies to the soil aquifer medium. Since the contaminated soil aquifer medium present at the site is recharged by the contaminated fracture system aquifer (see Section 2.4.2.2), soil flushing will not remediate the source of contamination. The fracture system will continue to provide a constant source of contaminants to the soil aquifer system. It is also necessary that contaminants be extracted once they are mobilized. To remove the contaminants from the aquifer, it is necessary to turn to other methods evaluated herein (i.e.: pump and treat, etc.).

EPA analysis of FS and ROD data from CERCLA municipal landfill sites (contained herein Appendix III) indicates that soil flushing methods were screened out of consideration for a total of 14 out of 16 facilities.

In Situ Steam Stripping

In situ steam stripping is an technology used to enhance the volatilization of organic compounds in the soil. Steam is injected and mixed into the ground through specially adapted hollow core drill stems. Volatilized organic compounds rise to the surface and are collected via a blower system. The collected gases are treated to condense the organics and trap the remainder on activated carbon. Once treated, the gases are reheated and reinjected.

Once again, this remediation method is only applicable to the soil aquifer medium. Since the contaminated soil aquifer medium present at the site is recharged by the

contaminated fracture system aquifer (see Section 2.4.2.2), in situ steam stripping will not remediate the source of contamination. The fracture system will continue to provide a constant source of contaminants to the soil aquifer system. Only by focusing on containment as the presumptive remedy will active restoration be feasible.

EPA analysis of FS and ROD data from CERCLA municipal landfill sites (contained herein Appendix III) indicates that situ steam stripping methods were screened out of consideration for a total of 5 out of 5 facilities.

Soil Vapor Extraction

Soil vapor extraction has been used at several sites to augment groundwater extraction and treatment. This technology can be applied using a variety of system designs, depending on site conditions. A vacuum is applied to subsurface soils in the unsaturated zone and in dewatered portions of the saturated zone. The extracted vapor or soil gas contains volatile contaminants that can be either vented directly to the atmosphere or collected in a vapor-phase carbon adsorption system. The system may consist of a single extraction well screened in the contaminated zone, or it may include inlet wells that direct air flow through a particular interval.

Once again, this remediation method only applies to the soil aquifer medium. Since the contaminated soil aquifer medium present at the site is recharged by the contaminated fracture system aquifer (see Section 2.4.2.2), soil vapor extraction will not remediate the source of contamination. The fracture system will continue to provide a constant source of contaminants to the soil aquifer system.

EPA analysis of FS and ROD data from CERCLA municipal landfill sites (contained herein Appendix III) indicates that soil vapor extraction methods were screened out of consideration for a total of 11 out of 14 facilities.

Conclusions

The objective of the EPA's presumptive remedies initiative for municipal landfill sites is to use the past experience of the Superfund Program to streamline and speed up selection and implementation of cleanup actions. Presumptive remedies are preferred remedial responses, based on historical patterns of remedy selection and EPA's scientific and engineering evaluation of performance data on technology implementation. A detailed summary of the information from the technology screening and remedial alternative analysis is provided in Appendix A of the Presumptive Remedy Directive (contained herein Appendix III). EPA's analysis demonstrates that containment (the presumptive remedy) was chosen as a component of the remedial response at all thirty of the site analyzed. No other technologies were consistently selected or retained for consideration.

6.3 Risk Assessment

contaminated fracture system aquifer (see Section 2.4.2.2), in situ steam stripping will not remediate the source of contamination. The fracture system will continue to provide a constant source of contaminants to the soil aquifer system. Only by focusing on containment as the presumptive remedy will active restoration be feasible.

EPA analysis of FS and ROD data from CERCLA municipal landfill sites (contained herein Appendix III) indicates that situ steam stripping methods were screened out of consideration for a total of 5 out of 5 facilities.

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Once again, this remediation method only applies to the soil aquifer medium. Since the contaminated soil aquifer medium present at the site is recharged by the contaminated fracture system aquifer (see Section 2.4.2.2), soil vapor extraction will not remediate the source of contamination. The fracture system will continue to provide a constant source of contaminants to the soil aquifer system.

EPA analysis of FS and ROD data from CERCLA municipal landfill sites (contained herein Appendix III) indicates that soil vapor extraction methods were screened out of consideration for a total of 11 out of 14 facilities.

Conclusions

The objective of the EPA's presumptive remedies initiative for municipal landfill sites is to use the past experience of the Superfund Program to streamline and speed up selection and implementation of cleanup actions. Presumptive remedies are preferred remedial responses, based on historical patterns of remedy selection and EPA's scientific and engineering evaluation of performance data on technology implementation. A detailed summary of the information from the technology screening and remedial alternative analysis is provided in Appendix A of the Presumptive Remedy Directive (contained herein Appendix III). EPA's analysis demonstrates that containment (the presumptive remedy) was chosen as a component of the remedial response at all thirty of the site analyzed. No other technologies were consistently selected or retained for consideration.

6.3 Risk Assessment

A baseline risk assessment will be conducted in conjunction with the acquisition of additional remedial assessment data to assess potential risks posed by the site. The baseline risk assessment will include four major components:

- contaminant identification,
- exposure assessment,
- toxicity assessment, and
- risk characterization.

The baseline risk assessment will address all four components noted above to varying degrees based on the site complexity. Further discussion of the baseline risk assessment components will be detailed in a formal Risk Assessment proposal to be submitted for NCDEHNR review and approval.

The results of the potable well sampling program will continue to assist ongoing risk assessment investigations within areas not fully characterized by the existing monitoring well network Continued modeling of the site will utilize Draper Aden Environmental Modeling's (DAEM) service's to assist risk assessment and management services.

6.4 Summary/Recommendations

Based on an evaluation of remedial alternatives, the most cost effective and technically justified remedial action proposed for this site is containment, supplemented by a risk assessment, institutional controls, natural attenuation, and continuing investigation of certain issues. Site conditions preclude the use of invasive, direct remedial activities. Source containment and natural attenuation are the most effective solutions to environmental impacts at the site.

Further support for allowing natural attenuation to remediate subsurface impacts is provided by target parameter concentration and distribution trends observed during background assessment monitoring. Target parameter concentration and distribution trends indicate steady state conditions, where sourcing of contaminants is balanced by removal, are predominant across the site. Migration of detectable concentrations of the target parameters beyond the current boundary is not anticipated. Although the current assessment background monitoring data does not provide conclusive evidence of steady state conditions, additional assessment monitoring in the coming years will provide the temporal data to properly assess contaminant transportation, migration, and fate trends. Continued modeling of the site will utilize Draper Aden Environmental Modeling's (DAEM) services to assist in furthering the understanding of fate and transport mechanisms, risk assessment, and site management.

As steady state conditions continue to be observed at the site, capping of the disposal area will assist in diminishing leachate production, and thus contaminant migration. Natural attenuation processes will assist in lowering the concentrations of the target parameters, and with source controls in place, should provide for continuously diminished contaminant concentrations.

VII. REMEDIAL CAP COSTS

As previously discussed, placement of a remedial cap on the approximately 20 acre disposal area at Watauga facility is proposed as an immediate remedial action for NCDEHNR review and approval. Through the reduction of infiltration in the landfill's disposal area, contaminant sourcing should be reduced. This alternative provides Watauga County with the most cost-effective immediate action available as the County seeks to develop a practical, site-warranted, and comprehensive site response based on ongoing assessment investigations and modeling of the site.

Costs for the cap were evaluated using the Means, 1995 Construction Guide and information received from recent bids for similar facilities. For costing, the drainage medium was assumed to be a heavy, 16 oz. geotextile. Alternatives to this include use of a geonet/geocomposite or a 6" gravel layer. Final design will determine the most cost effective solution. The geotextile does not drain as well as the geonet but still reduces the infiltration to 10,000 gal/ac/day vs. 390,000 gal/ac/day.

The costs were also compared against cost estimates prepared by NCDEHNR for a similar cap.

ITEM	UNIT COST	UNIT	TOTAL COST (PER ACRE)
Topsoil (6")	$3.25	806 cy	$2,619
Cushion (18")	$4.50	2420 cy	$10,980
Geotextile (16 oz)	$0.20	43560 sf	$8,712
Membrane (40 mil)	$0.40	43560 sf	$17,424
Bedding (12")	$3.57	1612 cy	$5,755
Subtotal			$45,400
Contingency			$4,540
			$49,940
Vents			$3,000
Other (Erosion Control, etc.)			$10,000
Total			$62,940

NCDEHNR estimated a total cost of $40,000/acre for a similar cap, however, they did not include a filter fabric protective layer between the gravel and membrane (estimated at $8,700/acre), they did not include a contingency to reflect the volatile construction market and location of Watauga, and they did not include a specifically prepared bedding layer.

Relative to recent construction of membrane caps, Draper Aden Associates has received the following bids:

Bedford County, Virginia	20 Acres	$67,000/Acre
Giles County, Virginia	6 Acres	$106,000/Acre
Floyd County, Virginia	6 Acres	$92,600/Acre

These bids reflect the benefits of the economy of scale of the larger landfills and problems with accessibility and market fluctuations.

VIII. SCHEDULE

Construction of the cap will require design of the cap and procurement of a contractor. The proposed implementation schedule may be summarized as follows:

Public Participation Session	January 16, 1996
Public Coment Period Ends	January 26, 1996
Board of Commissioners Consideration	February 5, 1996
Completion of Proposed Remedial Design	February 8, 1996
NCDEHNR Approval	February 8 - March 1, 1996
Advertisement and Bid	March 1 - March 30, 1996
Award of Contract	April 1 - April 15, 1996
Construction	April 16 - August 31, 1996

Because of the severity of weather in the Watauga County area, it is critical to initiate the construction as soon as possible this spring. Timely approval of this remedial option will help facilitate implementation.

IX. PROJECT MANAGEMENT

Construction of the cap will be managed by Draper Aden Associates on behalf of the County. Field QA/QC will include soil compaction testing, surveying of the depths of the various layers, and inspection/testing on the membrane. Upon completion, a final certification package will be prepared for submittal to DEHNR.

occur as a result of upsetting the equilibrium of the aquifer system. Contaminants residing in dead zones of the aquifer system can be released due to gradient changes, resulting in impacts to portions of the aquifer not currently affected.

Containment utilizing slurry walls would be hindered by the depth and associated aquifer media encountered across the site (as presented herein Section 2.4.2.1). A slurry wall could only be feasibly utilized within the soil aquifer medium and the association of the soil aquifer medium with the bedrock aquifer medium would severely reduce the effectiveness of the remedial application of the slurry wall.

Extraction and Treatment

An extraction system can be used to remove contaminated groundwater, followed by treatment, if required, and discharge or reinjection back into the aquifer. Extraction can be achieved by using pumping wells, French drains, or trenches. Pumping may be continuous or pulsed to remove contaminants after they have been given time to desorb from the aquifer material and equilibrate with groundwater. Treatment may involve air-stripping, carbon absorption, and biological treatment, depending on the physical/chemical properties of the contaminants.

The site specific hydrological constraints posed by contaminant migration into the fractured bedrock present beneath the site limit the effectiveness of site-wide active restoration by pump and treat methods, since contaminants can migrate into formations from which they cannot be effectively removed (see Section 2.4.2). Although some level of contaminant removal by pump and treat methods can usually be achieved, complete removal and treatment of contaminated groundwater is not feasible due the lingering effects of residual contaminants both absorbed to the aquifer medium and remaining in dead zones of the fracture system.

Biorestoration

Biorestoration relies on microorganisms to transform hazardous compounds into innocuous materials. Almost all organic compounds and some inorganic compounds can be degraded biologically if given the proper physical and chemical conditions and sufficient time. Some organic compounds readily biodegrade, while other molecules degrade at a much slower rate. Some organic compounds are toxic to microorganisms or inhibit their activity. In some cases, such as with the degradation of trichloroethylene to vinyl chloride, the by-products are more toxic than the parent compound.

Biorestoration is a passive process that occurs naturally in many aquifer systems, whether anaerobic or aerobic. Although attempts can be made to augment the biorestoration process by supplying nutrients and/or microorganisms to the aquifer systems, often biorestoration processes are already in place. Distinct biorestoration mechanisms may be active within different aquifer mediums as well as within different zones of the same aquifer medium.

The effectiveness of various bioremediation techniques are highly dependent on both site specific aquifer medium characteristics as well as the composition of compounds found at the site. Although one bioremediation method may be feasible at one location, site-wide application of one individual remediation method would not likely be effective. The variety of organic compounds found at the site also would limit the applicability and effectiveness of various bioremediation techniques. Individual microorganisms may remediate some organic compounds, while some organic compounds may be toxic to the same microorganisms. No microorganism would likely be effective in remediating all the organic compounds.

EPA analysis of FS and ROD data from CERCLA municipal landfill sites (contained herein Appendix III) indicates that both in-situ and ex-situ bioremediation methods were screened out of consideration for a total of 24 out of 25 facilities.

Soil Flushing

Soil flushing refers to applying a liquid flushing agent to contaminated soil to physically or chemically remove contaminants absorbed to the aquifer medium. As the term “soil flushing” implies, this remediation method only applies to the soil aquifer medium. Since the contaminated soil aquifer medium present at the site is recharged by the contaminated fracture system aquifer (see Section 2.4.2.2), soil flushing will not remediate the source of contamination. The fracture system will continue to provide a constant source of contaminants to the soil aquifer system. It is also necessary that contaminants be extracted once they are mobilized. To remove the contaminants from the aquifer, it is necessary to turn to other methods evaluated herein (i.e.: pump and treat, etc.).

EPA analysis of FS and ROD data from CERCLA municipal landfill sites (contained herein Appendix III) indicates that soil flushing methods were screened out of consideration for a total of 14 out of 16 facilities.

In Situ Steam Stripping

In situ steam stripping is an technology used to enhance the volatilization of organic compounds in the soil. Steam is injected and mixed into the ground through specially adapted hollow core drill stems. Volatilized organic compounds rise to the surface and are collected via a blower system. The collected gases are treated to condense the organics and trap the remainder on activated carbon. Once treated, the gases are reheated and reinjected.

Once again, this remediation method is only applicable to the soil aquifer medium. Since the contaminated soil aquifer medium present at the site is recharged by the

contaminated fracture system aquifer (see Section 2.4.2.2), in situ steam stripping will not remediate the source of contamination. The fracture system will continue to provide a constant source of contaminants to the soil aquifer system. Only by focusing on containment as the presumptive remedy will active restoration be feasible.

EPA analysis of FS and ROD data from CERCLA municipal landfill sites (contained herein Appendix III) indicates that situ steam stripping methods were screened out of consideration for a total of 5 out of 5 facilities.

Soil Vapor Extraction

Soil vapor extraction has been used at several sites to augment groundwater extraction and treatment. This technology can be applied using a variety of system designs, depending on site conditions. A vacuum is applied to subsurface soils in the unsaturated zone and in dewatered portions of the saturated zone. The extracted vapor or soil gas contains volatile contaminants that can be either vented directly to the atmosphere or collected in a vapor-phase carbon adsorption system. The system may consist of a single extraction well screened in the contaminated zone, or it may include inlet wells that direct air flow through a particular interval.

Once again, this remediation method only applies to the soil aquifer medium. Since the contaminated soil aquifer medium present at the site is recharged by the contaminated fracture system aquifer (see Section 2.4.2.2), soil vapor extraction will not remediate the source of contamination. The fracture system will continue to provide a constant source of contaminants to the soil aquifer system.

EPA analysis of FS and ROD data from CERCLA municipal landfill sites (contained herein Appendix III) indicates that soil vapor extraction methods were screened out of consideration for a total of 11 out of 14 facilities.

Conclusions

The objective of the EPA's presumptive remedies initiative for municipal landfill sites is to use the past experience of the Superfund Program to streamline and speed up selection and implementation of cleanup actions. Presumptive remedies are preferred remedial responses, based on historical patterns of remedy selection and EPA's scientific and engineering evaluation of performance data on technology implementation. A detailed summary of the information from the technology screening and remedial alternative analysis is provided in Appendix A of the Presumptive Remedy Directive (contained herein Appendix III). EPA's analysis demonstrates that containment (the presumptive remedy) was chosen as a component of the remedial response at all thirty of the site analyzed. No other technologies were consistently selected or retained for consideration.

6.3 Risk Assessment

contaminated fracture system aquifer (see Section 2.4.2.2), in situ steam stripping will not remediate the source of contamination. The fracture system will continue to provide a constant source of contaminants to the soil aquifer system. Only by focusing on containment as the presumptive remedy will active restoration be feasible.

EPA analysis of FS and ROD data from CERCLA municipal landfill sites (contained herein Appendix III) indicates that situ steam stripping methods were screened out of consideration for a total of 5 out of 5 facilities.

Soil Vapor Extraction

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EPA analysis of FS and ROD data from CERCLA municipal landfill sites (contained herein Appendix III) indicates that soil vapor extraction methods were screened out of consideration for a total of 11 out of 14 facilities.

Conclusions

The objective of the EPA's presumptive remedies initiative for municipal landfill sites is to use the past experience of the Superfund Program to streamline and speed up selection and implementation of cleanup actions. Presumptive remedies are preferred remedial responses, based on historical patterns of remedy selection and EPA's scientific and engineering evaluation of performance data on technology implementation. A detailed summary of the information from the technology screening and remedial alternative analysis is provided in Appendix A of the Presumptive Remedy Directive (contained herein Appendix III). EPA's analysis demonstrates that containment (the presumptive remedy) was chosen as a component of the remedial response at all thirty of the site analyzed. No other technologies were consistently selected or retained for consideration.

6.3 Risk Assessment

A baseline risk assessment will be conducted in conjunction with the acquisition of additional remedial assessment data to assess potential risks posed by the site. The baseline risk assessment will include four major components:

- contaminant identification,
- exposure assessment,
- toxicity assessment, and
- risk characterization.

The baseline risk assessment will address all four components noted above to varying degrees based on the site complexity. Further discussion of the baseline risk assessment components will be detailed in a formal Risk Assessment proposal to be submitted for NCDEHNR review and approval.

The results of the potable well sampling program will continue to assist ongoing risk assessment investigations within areas not fully characterized by the existing monitoring well network Continued modeling of the site will utilize Draper Aden Environmental Modeling's (DAEM) service's to assist risk assessment and management services.

6.4 Summary/Recommendations

Based on an evaluation of remedial alternatives, the most cost effective and technically justified remedial action proposed for this site is containment, supplemented by a risk assessment, institutional controls, natural attenuation, and continuing investigation of certain issues. Site conditions preclude the use of invasive, direct remedial activities. Source containment and natural attenuation are the most effective solutions to environmental impacts at the site.

Further support for allowing natural attenuation to remediate subsurface impacts is provided by target parameter concentration and distribution trends observed during background assessment monitoring. Target parameter concentration and distribution trends indicate steady state conditions, where sourcing of contaminants is balanced by removal, are predominant across the site. Migration of detectable concentrations of the target parameters beyond the current boundary is not anticipated. Although the current assessment background monitoring data does not provide conclusive evidence of steady state conditions, additional assessment monitoring in the coming years will provide the temporal data to properly assess contaminant transportation, migration, and fate trends. Continued modeling of the site will utilize Draper Aden Environmental Modeling's (DAEM) services to assist in furthering the understanding of fate and transport mechanisms, risk assessment, and site management.

As steady state conditions continue to be observed at the site, capping of the disposal area will assist in diminishing leachate production, and thus contaminant migration. Natural attenuation processes will assist in lowering the concentrations of the target parameters, and with source controls in place, should provide for continuously diminished contaminant concentrations.

VII. REMEDIAL CAP COSTS

As previously discussed, placement of a remedial cap on the approximately 20 acre disposal area at Watauga facility is proposed as an immediate remedial action for NCDEHNR review and approval. Through the reduction of infiltration in the landfill's disposal area, contaminant sourcing should be reduced. This alternative provides Watauga County with the most cost-effective immediate action available as the County seeks to develop a practical, site-warranted, and comprehensive site response based on ongoing assessment investigations and modeling of the site.

Costs for the cap were evaluated using the Means, 1995 Construction Guide and information received from recent bids for similar facilities. For costing, the drainage medium was assumed to be a heavy, 16 oz. geotextile. Alternatives to this include use of a geonet/geocomposite or a 6" gravel layer. Final design will determine the most cost effective solution. The geotextile does not drain as well as the geonet but still reduces the infiltration to 10,000 gal/ac/day vs. 390,000 gal/ac/day.

The costs were also compared against cost estimates prepared by NCDEHNR for a similar cap.

ITEM	UNIT COST	UNIT	TOTAL COST (PER ACRE)
Topsoil (6")	$3.25	806 cy	$2,619
Cushion (18")	$4.50	2420 cy	$10,980
Geotextile (16 oz)	$0.20	43560 sf	$8,712
Membrane (40 mil)	$0.40	43560 sf	$17,424
Bedding (12")	$3.57	1612 cy	$5,755
Subtotal			$45,400
Contingency			$4,540
			$49,940
Vents			$3,000
Other (Erosion Control, etc.)			$10,000
Total			$62,940

NCDEHNR estimated a total cost of $40,000/acre for a similar cap, however, they did not include a filter fabric protective layer between the gravel and membrane (estimated at $8,700/acre), they did not include a contingency to reflect the volatile construction market and location of Watauga, and they did not include a specifically prepared bedding layer.

Relative to recent construction of membrane caps, Draper Aden Associates has received the following bids:

Bedford County, Virginia	20 Acres	$67,000/Acre
Giles County, Virginia	6 Acres	$106,000/Acre
Floyd County, Virginia	6 Acres	$92,600/Acre

These bids reflect the benefits of the economy of scale of the larger landfills and problems with accessibility and market fluctuations.

VIII. SCHEDULE

Construction of the cap will require design of the cap and procurement of a contractor. The proposed implementation schedule may be summarized as follows:

Public Participation Session	January 16, 1996
Public Coment Period Ends	January 26, 1996
Board of Commissioners Consideration	February 5, 1996
Completion of Proposed Remedial Design	February 8, 1996
NCDEHNR Approval	February 8 - March 1, 1996
Advertisement and Bid	March 1 - March 30, 1996
Award of Contract	April 1 - April 15, 1996
Construction	April 16 - August 31, 1996

Because of the severity of weather in the Watauga County area, it is critical to initiate the construction as soon as possible this spring. Timely approval of this remedial option will help facilitate implementation.

IX. PROJECT MANAGEMENT

Construction of the cap will be managed by Draper Aden Associates on behalf of the County. Field QA/QC will include soil compaction testing, surveying of the depths of the various layers, and inspection/testing on the membrane. Upon completion, a final certification package will be prepared for submittal to DEHNR.

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APPENDIX 1

TABLES AND FIGURES

Table 1

Watauga County Landfill
Groundwater and Surface Water
Assessment Monitoring Schedule

GROUNDWATER MONITORING	1st Year Quarterly Sampling Event				2nd Year Semi-Annual Sampling Events	
"CORE" ASSESSMENT WELLS						
Assessment Monitoring Parameters (ie: 40 CFR Part 258 Appendix II List)	-	-	-	-	Low Level Risk Assessment Screening Methods	-
Target Parameter Monitoring Parameters	CLP Methods	CLP Methods	CLP Methods	CLP Methods	-	CLP Methods
"BOUNDARY" ASSESSMENT WELLS						
Target Parameter Monitoring Parameters	LLRA Methods	CLP Methods	LLRA Methods	CLP Methods	LLRA Methods	CLP Methods
SURFACE WATER MONITORING						
Target Parameter Monitoring Parameters	CLP Methods	-	CLP Methods	-	CLP Methods	CLP Methods

CLP - EPA Contract Laboratory Program Methods
LLRA - Low Level Risk Assessment Screening Methods (EPA SW-846)

Watauga County Landfill
Watauga County, North Carolina
Upgradient Well: MW-1
11/8/95

Table 2A

First Semi-Annual Monitoring Event
Assessment Target Parameter Analytical Results
Core Groundwater Monitoring Wells - Inorganic and Organic Analyses
Contract Laboratory Program (CLP) Statements of Work (SOW) - Metals (1)
Low Level Risk Assessment (LLRA) SW-846 Method 8260- Organics (2)

Parameters	Event	Results ug/L(ppb)																							
		MW-1		MW-2		MW-3		MW-6		MW-7		MW-8		MW-9		MW-10		MW-11		MW-12		MW-17		NCS (ug/L)	MCL (ug/L)
METALS, TOTAL																									
Barium, Total	7/10/95	125		210	J	94.5		499		-		70.6		612		103		199		110		79		2000	2000
Iron, Total	7/10/95	646		9.7	U*	4480		7980		-		455		9.7	U*	508		9.7	U	9.7	U*	48.5		300*	300*
Cadmium, Total	7/10/95	0.5	U	0.5	U	0.5	U	0.5	U	-		0.5	U	0.5	U	0.5	U	0.5	U	0.5	U	0.5	U	5.0	5.0
Mercury, Total	7/10/95	0.2	U	0.2	U	0.2	U	0.2	U	-		0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	1.1	2.0
ORGANICS																									
Benzene	7/10/95	5	U	5	U	2.6	J	13		2.7	J	5.5		3.8	J	5	U	5	U	5	U	5	U	1	5
Chloroethane	7/10/95	5	U	5	U	8.7		16		22		9.3		21		5	U	5	U	6.4		4.9	J	-	-
Dichlorodifluoromethane	7/10/95	5	U	5	U	7.2		2.2	J	5	U	6.7		2.8	J	5	U	1.7	J	4.0	J	4.2	J	0.19	-
1,1-Dichloroethane	7/10/95	5	U	94		160		130		6.8		71		40		55		26		120		130		700**	-
1,1 Dichloroethene	7/10/95	5	U	170	J	3.7	J	1.3	J	5	U	4.1	J	5	U	88		5	U	3.6	J	1.6	J	7	7
1,2 Dichloroethene(cis)	7/10/95	5	U	5	U	50		430		7.9		89		6.2		5	U	7.6		42		63		70	70
trans 1,3-Dichloropropene	7/10/95	5	U	5	U	5	U	5	U	5	U	5	U	5	U	5	U	5	U	5	U	5	U	-	-
Methylene Chloride	7/10/95	5	U	5	U	5	U	5	U	5	U	5	U	160		5	U	5	U	5.9	U	5	U	5	5
Tetrachloroethene	7/10/95	5	U	9.9		37		14		5	U	38		3.6	J	5.7		8.1		31		30		0.7	5
Trichloroethene	7/10/95	5	U	5	U	16		47		1.2	J	15		6		5	U	3.1	J	13		17		2.8	5
1,1,1-Trichloroethane	7/10/95	5	U	1600		21		5	U	5	U	4.9	J	9.8		740		4.8	J	16		7		200	200
Vinyl Chloride	7/10/95	5	U	5	U	3.1	J	23		5	U	7.2		5	U	5	U	5	U	5	U	5	U	0.015	2

Notes:
NCS Denotes North Carolina Groundwater Quality Standard (T15A: 02L .0200)
MCL Denotes EPA Maximum Contaminant Level (EPA 822-R-94-001)
U Denotes not detected above Instrument Detection Level (IDL) for Inorganics and not detected above CRQL for Organics
U* Denotes sample result is less than 5 times corresponding blank concentration (termed sample LOQ).
J Denotes an estimated value
CRQL Contract Required Quantification Limit
* Denotes a Secondary Maximum Contaminant Level (SMCL) for Total Iron
** Denotes a proposed NCS
- Denotes Not Avaliable or Not Sampled
Shading denotes parameter results that exceed U.S. EPA Maximum Contaminant Levels.
(1) Metal parameters were analyzed in accordance with EPA Contract Laboratory Program (CLP) Statement of Work ILMO 3.0.
CLP analytical methods utilize relevant Atomic Adsorption technique and Inductively Coupled Plasma (ICP) method for metal analysis
(2) Organic parameters were analyzed in accordance with USEPA SW-846 Method 8260 .

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Watauga County Landfill
Watauga County, North Carolina
Upgradient Well: MW-1
11/8/95

Table 2B

First Semi-Annual Monitoring Event
Assessment Target Parameter Analytical Results
Boundary Groundwater Monitoring Wells and Surface Water Sampling Locations - Inorganic and Organic Analyses
Contract Laboratory Program (CLP) Statement of Work (SOW) (1) (2)

Parameters	Event	Results ug/L(ppb)																								NCS (ug/L)	MCL (ug/L)
		MW-4		MW-5		MW-13		MW-14		MW-15		MW-16		MW-18		S-1		S-2		S-3		S-4		S-5			
METALS, TOTAL																											
Barium, Total	7/10/95	23.8		700		116		19.5		73.6		67		90		502		592		277		861		310		2000	2000
Iron, Total	7/10/95	9.7	U*	9.7	U	3960		9.7	U*	21.2		9.7	U*	9.7	U*	19400		36100		5740		1290		87900		300*	300*
Cadmium, Total	7/10/95	0.5	U	0.5	U	0.5	U	0.5	U	0.5	U	0.5	U	0.5	U	4.2	U	4.2	U	4.2	U	4.2	U	4.2	U	5	5
Mercury, Total	7/10/95	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	1.1	2
ORGANICS																											
Benzene	7/10/95	10	U	-		-		-		-		-		-		10	U	10	U	10	U	10	U	10	U	1	5
Chloroethane	7/10/95	10	U	-		-		-		-		-		-		15		10	U	10	U	4	J	10		-	-
Dichlorodifluoromethane	7/10/95	10	U	-		-		-		-		-		-		10	UJ	10	UJ	10	UJ	10	UJ	3	J	0.19	-
1,1-Dichloroethane	7/10/95	10	U	-		-		-		-		-		-		6	J	20		10	U	41		2	J	700**	-
1,1-Dichloroethene	7/10/95	10	U	-		-		-		-		-		-		10	U	10	U	10	U	10	U	10	U	7	7
1,2-Dichloroethene(cis)	7/10/95	10	U	-		-		-		-		-		-		1	J	3	J	10	U	42		10	U	70	70
trans-1,3-Dichloropropene	7/10/95	10	U	-		-		-		-		-		-		10	U	10	U	10	U	10	U	10	U	-	-
Methylene Chloride	7/10/95	10	U	-		-		-		-		-		-		10	U	10	U	10	U	10	U	10	U	5	5
Tetrachloroethene	7/10/95	10	U	-		-		-		-		-		-		10	U	10	U	10	U	11		10	U	0.7	5
Trichloroethene	7/10/95	10	U	-		-		-		-		-		-		10	U	1	J	10	U	8	J	10	U	2.8	5
1,1,1-Trichloroethane	7/10/95	10	U	-		-		-		-		-		-		10	U	1	J	10	U	2	J	10	U	200	200
Vinyl Chloride	7/10/95	10	U	-		-		-		-		-		-		10	U	10	U	10	U	3	J	10	U	0.015	2

Notes:
NCS Denotes North Carolina Groundwater Quality Standard (T15A: 02L .0200)
MCL Denotes EPA Maximum Contaminant Level (EPA 822-R-94-001)
CRQL Contract Required Quantification Limit
U Denotes not detected above Instrument Detection Level(IDL) for Inorganics and not detected above CRQL for Organics
U* Denotes sample result is less than 5 times corresponding blank concentration (termed sample LOQ).
J Denotes an estimated value
* Denotes a Secondary Maximum Contaminant Level (SMCL) for Total Iron
** Denotes a proposed NCS
- Denotes Not Avaliable or Not Sampled
Shading denotes parameter results that exceed U.S. EPA Maximum Contaminant Levels.
(1)Metal Parameters were analyzed in accordance with EPA Contract Laboratory Program (CLP) Statement of Work ILMO 3.0.
CLP analytical methods utilize relevant Atomic Adsorption technique and Inductively Coupled Plasma (ICP) method for metal analysis.
(2)Organic parameters for S1 through S5 were analyzed in accordance with USEPA CLP SOW OLMO1.9(3/90).
For CLP analysis, 1,2-Dichloroethene was reported as total concentration rather than as cis-omer.
Organic parameters for MW-4 were analyzed in accordance with SW-846 Method 8260.

Watauga County Landfill
Watauga County, North Carolina
Upgradient Well: MW-1
12/11/95

Table 2C

First Semi-Annual Monitoring Event
Assessment Target Parameter Analytical Results
Core Groundwater Monitoring Wells - Organic Analyses
Low Level Risk Assessment (LLRA) SW846 Method 8021

Parameters	Event	Results ug/L(ppb)																						NCS	MCL
		MW-1		MW-2		MW-3		MW-6		MW-7		MW-8		MW-9		MW-10		MW-11		MW-12		MW-17		(ug/L)	(ug/L)
ORGANICS																									
Benzene	7/10/9	2.0	U	2.0	U	2.3		14		2.2		6.2		4.0		2.0	U	2.0	U	2.0	U	2.0	U	1	5
Chloroethane	7/10/9	2.0	U	2.0	U	10	U	15	U	9.2		10	U	20	U	2.0	U	2.0	U	5.0	U	5.0	U	-	-
Dichlorodifluoromethan	7/10/9	2.0	UJ	2.0	UJ	6.9	J	2.0	UJ	2.0	UJ	16	J	2.0	UJ	2.0	UJ	2.0	UJ	5.7	J	5.3	J	0.19	-
1,1-Dichloroethane	7/10/9	2.0	U	81		130		100	J	4.8		60	J	36		58	J	22		100		102	J	700**	-
1,1-Dichloroethene	7/10/9	2.0	U	170		4.0		2.0	U	2.0	U	5.7		2.0	U	160	J	0.86	J	3.9		1.8	J	7	7
1,2-Dichloroethene(cis)	7/10/9	2.0	U	2.0	U	65		440	J	4.4		110	J	7.4		2.0	U	11		37		72	J	70	70
rans-1,3-Dichloropropen	7/10/9	2.0	U	2.0	U	2.0	U	2.0	U	2.0	U	2.0	U	2.0	U	2.0	U	2.0	U	2.0	U	2.0	U	-	-
Methylene Chloride	7/10/9	2.0	U	2.0	U	2.4		1.2	J	2.0	U	4.7		89		2.0	U	2.9		3.3		2.2		5	5
Tetrachloroethene	7/10/9	2.0	U	12		31		13		2.0	U	42	J	5.0		13		10		27		40		0.7	5
Trichloroethene	7/10/9	2.0	U	1.2	J	20		67	J	1.6	J	28		8.6		2.0	U	5.8		16		21	J	2.8	5
1,1,1-Trichloroethane	7/10/9	2.0	U	1600		26		2.0	U	2.0	U	6.0		12		990		5.9		17		7.8		200	200
Vinyl Chloride	7/10/9	2.0	U	2.0	U	2.9	J	12	J	2.0	U	11	J	2.0	U	2.0	U	2.0	U	2.3		0.94	J	0.015	2

Notes:
NCS Denotes North Carolina Groundwater Quality Standard (T15A: 02L .0200)
MCL Denotes EPA Maximum Contaminant Level (EPA 822-R-94-001)
U Denotes not detected above Detection Level(IDL) for Inorganics and not detected above CRQL for Organics
U* Denotes sample result is less than 5 times corresponding blank concentration (termed sample LOQ).
J Denotes an estimated value
CRQL Contract Required Quantification Limit
** Denotes a proposed NCS
- Denotes Not Avaliable or Not Sampled
Shading denotes parameter results that exceed U.S. EPA Maximum Contaminant Levels.
Organic parameters were analyzed in accordance with USEPA SW-846 Method 8021.

Watauga County Landfill
Watauga County, North Carolina
Upgradient Well: MW-1
11/8/95

Table 2D

First Semi-Annual Monitoring Event
Assessment Target Parameter Analytical Results
Boundary Groundwater Monitoring Wells - Organic Analyses
Low Level Risk Assessment (LLRA) SW-846 Method 8021

Parameters	Event	Results ug/L(ppb)														NCS	MCL
		MW-4		MW-5		MW-13		MW-14		MW-15		MW-16		MW-18		(ug/L)	(ug/L)
ORGANICS																	
Benzene	7/10/95	2.0	U	2.0	U	2.0	U	2.0	U	2.0	U	2.0	U	2.0	U	1	5
Chloroethane	7/10/95	2.0	U	2.0	U	2.0	U	2.0	U	2.0	U	2.0	U	2.0	U	-	-
Dichlorodifluoromethane	7/10/95	2.0	U	2.0	UJ	2.0	UJ	2.0	U	2.0	U	2.0	U	2.0	UJ	0.19	-
1,1-Dichloroethane	7/10/95	2.0	U	2.0	U	2.0	U	2.0	U	2.0	U	2.0	U	2.0	U	700**	-
1,1-Dichloroethene	7/10/95	2.0	U	2.0	U	2.0	U	2.0	U	2.0	U	2.0	U	2.0	U	7	7
1,2-Dichloroethene(cis)	7/10/95	2.0	U	2.0	U	2.0	U	2.0	U	2.0	U	2.0	U	2.0	U	70	70
trans-1,3-Dichloropropene	7/10/95	2.0	U	2.0	U	2.0	U	2.0	U	2.0	U	2.0	U	2.0	U	-	-
Methylene Chloride	7/10/95	2.0	U	2.0	U	0.84	J	2.0	U	2.0	U	2.0	U	0.58	J	5	5
Tetrachloroethene	7/10/95	2.0	U	2.0	U	2.0	U	2.0	U	2.0	U	2.0	U	2.0	U	0.7	5
Trichloroethene	7/10/95	2.0	U	2.0	U	2.0	U	2.0	U	2.0	UJ	2.0	U	2.0	U	2.8	5
1,1,1-Trichloroethane	7/10/95	2.0	U	2.0	U	2.0	U	2.0	U	2.7		2.0	U	2.0	U	200	200
Vinyl Chloride	7/10/95	2.0	U	2.0	U	2.0	U	2.0	U	2.0	U	2.0	U	2.0	U	0.015	2

Notes:
NCS Denotes North Carolina Groundwater Quality Standard (T15A: 02L .0200)
MCL Denotes EPA Maximum Contaminant Level (EPA 822-R-94-001)
CRQL Contract Required Quantification Limit
U Denotes not detected above Instrument Detection Level(IDL) for Inorganics and not detected above CRQL for Organics
U* Denotes sample result is less than 5 times corresponding blank concentration (termed sample LOQ).
J Denotes an estimated value
** Denotes a proposed NCS
- Denotes Not Avaliable or Not Sampled
Shading denotes parameter results that exceed U.S. EPA Maximum Contaminant Levels.
Organic parameters were analyzed in accordance with SW-846 Method 8021.

Watauga County Landfill
Watauga County, North Carolina
Upgradient Well: MW-1
11/27/95

Table 3A
First Semi-Annual Assessment Monitoring Event
Detected Non-Target Organic Parameter Analytical Results

Parameter	Event	Method	Results ug/L (ppb)																		NCS (ug/L)	MCL (ug/L)
			MW-3		MW-6		MW-7		MW-8		MW-9		MW-10		MW-17		S-1		S-2			
Trichlorofluoromethane	7/10/95	8260	1.1	J	~		~		~		~		~		~		~		~		2,100	-
trans-1,2-Dichloroethene	7/10/95	8260	~		5.7		1.6	J	1.4	J	~		~		~		~		~		70	100
1,2,-Dichloroethane	7/10/95	8260	1.8	J	~		~		~		~		~		1.8	J	~		~		0.30	-
	7/10/95	8021	1.8	J	~		~		0.89	J	~		~		1.7	J	~		~		0.30	-
Bromomethane	7/10/95	8260	2.4	J	~		~		~		~		~		~		~		~		-	-
1,2-Dichloropropane	7/10/95	8260	1.0	J	1.0	J	1.6	J	~		~		~		~		~		~		0.56	5
	7/10/95	8021	~		~		1.4	J	0.87	J	~		~		~		~		~		0.56	5
1,4-Dichlorobenzene	7/10/95	8260	~		~		~		1.1	J	~		~		~		~		~		-	-
2-Butanone	7/10/95	8260	~		~		15		4.9	J	~		3.1	J	~		~		~		-	-
	7/10/95	CLP	~		~		~		~		~		~		~		~		5	J	-	-
o-xylene	7/10/95	8260	~		~		~		~		3.0	J	~		~		~		~		530	10000
m/p xylene	7/10/95	CLP	~		~		~		~		~		~		~		1	J	~		530	10000
total xylene	7/10/95	CLP	~		~		~		~		~		~		~		~		6	J	530	10000
toluene	7/10/95	CLP	~		~		~		~		~		~		~		~		2	J	1000	1000
ethylbenzene	7/10/95	CLP	~		~		~		~		~		~		~		~		3	J	29	700

Notes: NCS Denotes North Carolina Groundwater Quality Standard (T15A: 02L .0200)
MCL Denotes EPA Maximum Contaminant Level (EPA 822-R-94-001)
~ Denotes not detected above LOD/CRQL, as appropriate
- Denotes no applicable standard
J Denotes an estimated value
Shadin Denotes Parameter results that meet or exceed U.S. EPA Maximum Contaminant Levels
Organic parameters were analyzed in accordance with USEPA CLP SOW OLMO1.9(3/90), SW-846 Method 8260 and/or 8021

H:6520-21\TABLE3A.xls

Watauga County Landfill
Watauga County, North Carolina
Upgradient Well: MW-1
11/24/95

Table 3B
First Semi-Annual Assessment Monitoring Event
Non-Target Metal Parameter Analytical Results

Parameter	Event	Results ug/L(ppb)																							
		MW-1		MW-2		MW-3		MW-4		MW-6		MW-8		MW-9		MW-10		MW-11		MW-12		MW-17		NCS (ug/L)	MCL (ug/L)
Antimony	7/10/95	1.9	U	1.9	U	1.9	U	1.9	U	1.9	U	1.9	U	1.9	U	1.9	U	1.9	U	1.9	U	1.9	U	-	6
Arsenic	7/10/95	2.7	U	2.7	U	2.7	U	2.7	U	2.7	U	2.7	U	2.7	U	2.7	U	2.7	U	2.7	U	2.7	U	50	-
Beryllium	7/10/95	0.1	U*	0.1	U	0.1	U*	0.1	U	0.1	U*	0.1	U*	0.1	U	0.1	U*	0.1	U*	0.1	U	0.1	U*	-	4
Chromium	7/10/95	1.4		0.7	U	5.5		0.7	U	1.5		2.3		0.7	U	6.3		0.7	U	0.7	U	0.7	U	50	100
Cobalt	7/10/95	0.5	U*	0.5	U	1.9		0.5	U	19.7		1.5		5.2		0.5	U	4.7		0.5	U	2.1		-	-
Copper	7/10/95	0.5	U	0.5	U*	6.1		0.5	U*	0.5	U	0.5	U	0.5	U*	0.5	U*	0.5	U	0.5	U*	0.5	U	1000	1300
Cyanide	7/10/95	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U	154	-
Lead	7/10/95	1.6	U	1.6	U	2		1.6	U	1.6	U	1.6	U	1.6	U*	1.6	U	1.6	U	1.6	U	1.6	U	15	15
Nickel	7/10/95	2.4	U	2.4	U	2.4	U	2.4	U	7.6		2.9		2.4	U	5.4		2.4	U	2.4	U	2.4	U	100	100
Selenium	7/10/95	3.4	U	3.4	U	3.4	U	3.4	U	3.4	U	3.4	U	3.4	U	3.4	U	3.4	U	3.4	U	3.4	U	50	50
Silver	7/10/95	0.6	U	0.6	U	0.6	U	0.6	U	0.6	U	0.6	U	0.6	U	0.6	U	0.6	U	0.6	U	0.6	U	18	-
Tin	7/10/95	5.0	U	5.0	U	5.0	U	5.0	U	5.0	U	5.0	U	5.0	U	5.0	U	5.0	U	5.0	U	5.0	U	-	-
Thallium	7/10/95	1	UJ	1	U	1	UJ	U	U	1	UJ	1	UJ	1	U	1	UJ	1	UJ	1	U	1	UJ	-	2
Vanadium	7/10/95	1.5		2.4		10.6		1.3	U	0.74	U	3.8		1.9		2.0		0.6	U	0.78	U	0.88	U	-	-
Zinc	7/10/95	1.2	U*	1.2	U*	23.8		1.2	U*	1.2	U*	1.2	U*	1.2	U*	1.2	U*	1.2	U*	1.2	U*	1.2	U*	2100	-

Notes: NCS Denotes North Carolina Groundwater Quality Standard (T15A: 02L .0200)
MCL Denotes EPA Maximum Contaminant Level (EPA 822-R-94-001)
U Denotes not detected above Instrument Detection Limit (IDL) for Inorganics (CLP SOW only)
U* Denotes sample result is less than 5 times corresponding blank concentration (termed sample LOQ).
J Denotes an estimated value
- Denotes not available or not sampled
Shading denotes parameter results that exceed U.S. EPA Maximum Contaminant Levels.
CLP analytical methods utilize relevant Atomic Adsorbtion technique and Inductively Coupled Plasma(ICP) method , in accordance with EPA Contract Laboratory Program (CLP) Statement of Work ILMO 3.0 for metal analysis

Watauga County Landfill
Watauga County, North Carolina
Upgradient Well: MW-1

22-Nov-95

TABLE 4A
GROUNDWATER LEVEL DATA
MONITORING WELLS

	REFERENCE ELEVATION								
	MW-1	MW-2	MW-3	MW-4	MW-5	MW-6	MW-7	MW-8	MW-9
GROUND	3339.03	3151.24	3182.25	3150.06	3263.81	3262.55	3270.56	3235.39	3356.65
MEASURING POINT	3341.80	3152.94	3183.12	3152.52	3267.69	3266.04	3273.53	3239.77	3359.23

DATE	STATIC WATER LEVEL								
6/20/94	38.00	7.88	18.43	13.48	NM	44.12	23.03	17.68	59.35
9/27/94	39.69	7.51	17.42	10.45	NM	43.99	30.73	17.38	57.79
2/6/95	37.57	5.58	16.20	8.18	50.39	42.85	45.88	15.41	59.54
4/11/95	37.94	6.46	16.85	9.22	48.95	42.81	49.11	16.05	59.30
7/10/95	41.20	6.60	17.43	8.94	50.29	43.73	48.98	17.42	80.17

DATE	GROUNDWATER ELEVATION								
6/20/94	3303.80	3145.06	3164.69	3139.04	NM	3221.92	3250.50	3222.09	3299.88
9/27/94	3302.11	3145.43	3165.70	3142.07	NM	3222.05	3242.80	3222.39	3301.44
2/6/95	3304.23	3147.36	3166.92	3144.34	3217.30	3223.19	3227.65	3224.36	3299.69
4/11/95	3303.86	3146.48	3166.27	3143.30	3218.74	3223.23	3224.42	3223.72	3299.93
7/10/95	3300.60	3146.34	3165.69	3143.58	3217.40	3222.31	3224.55	3222.35	3279.06

	REFERENCE ELEVATION								
	MW-10	MW-11	MW-12	MW-13	MW-14	MW-15	MW-16	MW-17	MW-18
GROUND	3202.18	3156.44	3156.82	3117.39	3117	3117.15	3141.42	3181.14	3117.12
MEASURING POINT	3203.87	3159.6	3159.15	3119.72	3120	3120.65	3142.72	3183.62	3119.63

DATE	STATIC WATER LEVEL								
6/20/94	8.18	13.35	11.04	19.66	7.94	11.92	5.32	17.93	17.93
9/27/94	8.09	13.22	10.78	19.57	7.89	11.82	5.68	17.83	17.86
2/6/95	7.73	13.22	10.61	19.39	7.52	11.55	4.61	17.05	17.58
4/11/95	7.90	13.00	10.58	19.53	7.75	11.87	5.11	17.48	17.65
7/10/95	7.91	12.53	10.48	19.62	7.74	11.96	4.54	18.11	17.94

DATE	GROUNDWATER ELEVATION								
6/20/94	3195.69	3146.25	3148.11	3100.06	3112.06	3108.73	3137.40	3165.69	3101.70
9/27/94	3195.78	3146.38	3148.37	3100.15	3112.11	3108.83	3137.04	3165.79	3101.77
2/6/95	3196.14	3146.38	3148.54	3100.33	3112.48	3109.10	3138.11	3166.57	3102.05
4/11/95	3195.97	3146.60	3148.57	3100.19	3112.25	3108.78	3137.61	3166.14	3101.98
7/10/95	3195.96	3147.07	3148.67	3100.10	3112.26	3108.69	3138.18	3165.51	3101.69

1) ALL MEASUREMENTS IN FEET.
2) ALL ELEVATIONS REFERENCE MEAN SEA LEVEL.
3) MEASURING POINT (M.P.) IS FROM THE TOP OF WELL CASING.
4) NM - NOT MEASURED

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Watauga County Landfill
Watauga County, North Carolina
Upgradient Well: MW-1

22-Nov-95

TABLE 4B
GROUNDWATER LEVEL DATA

	REFERENCE ELEVATION						
	PZ-13	PZ-14	PZ-17	PZ-18	PZ-18A	PZ-22	PZ-23
GROUND	3195.05	3214.80	3217.62	3233.60	3233.95	3205.6	3221.74
MEASURING POINT	3198.33	3217.80	3220.79	3236.02	3236.86	3208.84	3225.27

DATE	STATIC WATER LEVEL						
6/20/94	12.75	17.26	14.47	16.80	17.30	14.29	24.68
9/27/94	12.29	16.64	14.06	16.47	17.77	13.99	23.50
2/6/95	10.71	13.66	12.88	13.66	13.60	12.86	22.44
4/11/95	12.39	15.82	13.79	15.39	15.92	13.25	23.26
7/10/95	13.07	18.47	15.24	16.41	16.49	14.15	23.71

DATE	GROUNDWATER ELEVATION						
6/20/94	3185.58	3200.54	3206.32	3219.22	3219.56	3194.55	3200.59
9/27/94	3186.04	3201.16	3206.73	3219.55	3219.09	3194.85	3201.77
2/6/95	3187.62	3204.14	3207.91	3222.36	3223.26	3195.98	3202.83
4/11/95	3185.94	3201.98	3207.00	3220.63	3220.94	3195.59	3202.01
7/10/95	3185.26	3199.33	3205.55	3219.61	3220.37	3194.69	3201.56

1) ALL MEASUREMENTS IN FEET.
2) ALL ELEVATIONS REFERENCE MEAN SEA LEVEL.
3) MEASURING POINT (M.P.) IS FROM THE TOP OF WELL CASING.

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Watauga County Landfill
Watauga County, North Carolina
Upgradient Well: MW-1
12/13/95

Table 5A
Background Assessment Organic Target Parameter Analytical Results
Core Groundwater Monitoring Wells and
Septic Field Wells

Parameter	Event	Results ug/l(ppb)																										Analysis	NCS	MCL
		MW-1		MW-2		MW-3		MW-6		MW-7		MW-8		MW-9		MW-10		MW-11		MW-12		MW-17		SFW-1		SFW-2		SFW-3		Type	(ug/L)	(ug/L)
		Organics																														
Benzene	#REF!	10	U	120	U	10	U	9	J	0.42	J	0.72	J	0.40	J	5.30	U	5.30	U	5.30	U	5.30	U	-		-		-		CLP/LLRA	1	5
	9/27/94	10	U	9	J	2	J	12	J	3	J	5	J	4	J	10	U	10	U	10	U	2	J	-		-		-		CLP	1	5
	2/06/95	10	U	150	U	2	J	12	J	3.6		5	J	2	J	50	U	10	U	10	U	10	U	10	U	10	U	10	U	CLP	1	5
	4/11/95	10	U	200	U	1	J	10	J	3	J	6	J	3	J	71	U	10	U	10	U	10	U	10	U	10	U	10	U	CLP	1	5
Chloroethane	#REF!	10	U	120	U	6	J	8	J	7.33	J	9.44		56.78	J	9.29	U	1.16	J	20.23		28.21		-		-		-		CLP/LLRA	-	-
	9/27/94	10	U	170	U	8	J	10	J	16		7	J	18		10	U	10	U	5	J	7	J	-		-		-		CLP	-	-
	2/06/95	10	U	150	U	7	J	11	J	28		7	J	17		50	U	10	U	4	J	5	J	10	U	10	U	10	U	CLP	-	-
	4/11/95	10	U	200	U	6	J	8	J	16		7	J	15		71	U	10	U	2	J	4	J	10	U	10	U	10	U	CLP	-	-
Dichlorodifluoromethane	#REF!	10	U	120	U	7	J	25	U	46.64	U	2.26	J	13.92	J	46.64	U	1.88	J	9.83	J	1.44	J	-		-		-		CLP/LLRA	0.19	-
	9/27/94	10	U	10	J	4	J	25	U	10	U	2	J	9	J	10	U	10	U	4	J	4	J	-		-		-		CLP	0.19	-
	2/06/95	10	U	150	U	10	U	25	U	1.0	U	14		27		50	U	2	J	10	U	12		10	U	10	U	10	U	CLP	0.19	-
	4/11/95	10	U	200	U	10	U	25	U	10	U	7	J	9	J	71	U	10	U	4	J	3	J	10	U	10	U	10	U	CLP	0.19	-
1,1-Dichloroethane	#REF!	10	U	75	J	160		97		10.42	J	35.33	J	13.63	J	28.62	J	25.23	J	82.77	J	105.03	J	-		-		-		CLP/LLRA	700**	-
	9/27/94	10	U	110	J	200		110		1	J	70		23		84		27		130		230		-		-		-		CLP	700**	-
	2/06/95	10	U	160		180		140		2.9		74		30		37	J	28		120		170		10	U	18		11		CLP	700**	-
	4/11/95	10	U	98	J	130		94		4	J	58		35		67	J	18		77		130		-		-		-		CLP	700**	-
1,1-Dichloroethene	#REF!	10	U	180		5	J	25	U	9.75	U	0.30	J	9.75	U	32.39		9.75	U	1.15	J	1.09	J	-		-		-		CLP/LLRA	7	7
	9/27/94	10	U	210		6	J	25	U	10	U	4	J	10	U	100		10	U	5	J	3	J	-		-		-		CLP	7	7
	2/06/95	10	U	380		6	J	25	U	1.0	U	6	J	10	U	100		10	U	4	J	3	J	10	U	10	U	10	U	CLP	7	7
	4/11/95	10	U	150	J	3	J	25	U	10	U	3	J	10	U	120		10	U	2	J	1	J	-		-		-		CLP	7	7
cis 1,2-Dichloroethene(3)	#REF!	10	U	120	U	37		320		0.97	J	28.90		0.95	J	9.49	U	5.05	J	28.13		60.79	J	-		-		-		CLP/LLRA	70	70
	9/27/94	10	U	170	U	61		380		3	J	92		2	J	10	U	8	J	47		120		-		-		-		CLP	70	70
	2/06/95	10	U	150	U	64		270		7.2		81		2	J	50	U	8	J	37		80		10	U	6	J	3	J	CLP	70	70
	4/11/95	10	U	200	U	44		330		9	J	100		4	J	71	U	6	J	30		70		-		-		-		CLP	70	70
trans-1,3-Dichloropropene	#REF!	10	U	120	U	10	U	25	U	24.49	U	24.49	U	24.49	U	24.49	U	24.49	U	24.49	U	24.49	U	-		-		-		CLP/LLRA	-	-
	9/27/94	10	U	170	U	10	U	25	U	10	U	10	U	10	U	10	U	10	U	10	U	14	U	-		-		-		CLP	-	-
	2/06/95	10	U	150	U	10	U	25	U	1.0	U	10	U	10	U	50	U	10	U	10	U	10	U	10	U	10	U	10	U	CLP	-	-
	4/11/95	10	U	200	U	10	U	25	U	10	U	10	U	10	U	71	U	10	U	10	U	10	U	-		-		-		CLP	-	-
Methylene Chloride	#REF!	8	J	120	U	6	J	11	J	36.20	UJ	36.20	UJ	140.1	J	36.20	UJ	36.20	UJ	8.58	J	36.20	UJ	-		-		-		CLP/LLRA	5	5
	9/27/94	10	U	280		14	U	25	U	10	U	4	J	73		180		10	U	28	U	58	U	-		-		-		CLP	5	5
	2/06/95	10	U	150	U	10	U	25	U	1.5		10	U	83		50	U	10	U	10	U	10	U	2	J	10	U	2	J	CLP	5	5
	4/11/95	10	U	200	U	10	U	25	U	10	U	10	U	120		71	U	10	U	10	U	10	U	-		-		-		CLP	5	5
Tetrachloroethene	#REF!	10	U	120	U	44		6	J	0.88	J	7.55	J	2.15	J	1.30	J	7.47	J	22.78		27.43		-		-		-		CLP/LLRA	0.7	5
	9/27/94	10	U	170	U	33		28		10	U	33		5	J	12	J	9	J	36		64		-		-		-		CLP	0.7	5
	2/06/95	10	U	18	J	46		33		1.0	U	31		4	J	6	J	8	J	32		48		10	U	8	J	7	J	CLP	0.7	5
	4/11/95	10	U	200	U	33		19	J	10	U	38		5	J	10	J	7	J	26		41		-		-		-		CLP	0.7	5
Trichloroethene	#REF!	10	U	120	U	16		21	J	21.20	U	21.20	U	21.20	U	21.20	U	21.20	U	5.74	J	15.70	J	-		-		-		CLP/LLRA	2.8	5
	9/27/94	10	U	170	U	22		71		10	U	15		6	J	10	U	3	J	14		34		-		-		-		CLP	2.8	5
	2/06/95	10	U	150	U	15		68		2.5	U	14		6	J	50	U	3	J	12		24		10	U	2	J	2	J	CLP	2.8	5
	4/11/95	10	U	200	U	12		59		1	J	18		6	J	71	U	2	J	10		18		-		-		-		CLP	2.8	5
1,1,1-Trichloroethane	#REF!	10	U	1800		31		25	U	30.11	U	2.42	J	11.69	J	130.14	J	4.83	J	16.79	J	13.39	J	-		-		-		CLP/LLRA	200	200
	9/27/94	10	U	1600		35		25	U	10	U	6	J	18		1830		5	J	24		16		-		-		-		CLP	200	200
	2/06/95	10	U	2700		31		25	U	1.0	U	6	J	14		660		5	J	18		14		10	U	6	J	3	J	CLP	200	200
	4/11/95	10	U	3000		21		25	U	10	U	5	J	16		1300		5	J	17		10		-		-		-		CLP	200	200
Vinyl Chloride	#REF!	10	U	120	U	10	U	10	J	6.60	UJ	6.60	UJ	6.60	UJ	6.60	UJ	6.60	UJ	6.60	UJ	6.60	UJ	-		-		-		CLP/LLRA	0.15	2
	9/27/94	10	U	170	U	3	J	10	J	10	U	5	J	10	U	10	U	10	U	10	U	14	U	-		-		-		CLP	0.15	2
	2/06/95	10	U	150	U	2	J	20	J	3.8		6	J	10	U	50	U	10	U	10	U	10	U	10	U	10	U	10	U	CLP	0.15	2
	4/11/95	10	U	200	U	10	U	10	J	2	J	6	J	10	UJ	71	U	10	U	10	UJ	10	U	-		-		-		CLP	0.15	2

NOTES:
NCS Denotes North Carolina Groundwater Quality Standard (T15A: 02L .0200)
MCL Denotes EPA Maximum Contaminant Level (EPA 822-R-94-001)
U Denotes not detected above Instrument Detection Level(IDL) for Inorganics and not detected above CRQL for Organics (CLP SOW Only).
J Denotes an estimated value
CRQL Contract Required Quantification Limit
** Denotes a proposed NCS
- Denotes Not Avaliable or Not Sampled
Shading - denotes parameter results that exceed U.S. EPA Maximum Contaminant Levels.

1) CLP analytical methods utilize CLP Statement of Work OLMO1.9(3/90) for organic analysis
2) LLRA analytical methods utilize EPA SW-846 Method #8021
3)For CLP, 1,2-Dichloroethene was reported as total concentration; for LLRA concentration was reported for cis-isomer.
4)For the 6/20/94 event, monitoring wells MW-8, MW-9, MW-10, MW-11, MW-12, and MW-17, analyses were performed by using LLRA analytical methods. Other monitoring locations were analyzed using CLP analytical methods.

H/Eteam/6520-20/Table5A.xls

Watauga County Landfill
Watauga County, North Carolina
Upgradient Well: MW-1
12/07/95

Table 5B
Background Assessment Organic Target Parameter Analytical Results
Boundary Groundwater Monitoring Wells and Surface Water Sampling Locations

Parameter	Event	MW-4		MW-5		MW-13		MW-14		MW-15		MW-16		MW-18		S1		S2		S3		S4		S5		L1		Mt. Spring		Analysis Type	NCS (ug/L)	MCL (ug/L)
																ORGANICS																
Benzene	6/20/94	10	U	-		5.30	U	5.30	U	5.30	U	5.30	U	5.30	U	10	U	3	J	10	U	1	J	10	U	-		-		CLP/LLRA	1	5
	9/27/94	2	J	-		10	U	10	U	10	U	2	J	1	J	-		-		-		-		-		10	U	10	U	CLP	1	5
	2/06/95	10	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	10	U	10	U	10	U	10	U	10	U	10	U	-		CLP/LLRA	1	5
	4/11/95	10	U	10	U	10	U	10	U	10	U	10	U	10	U	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLP	1	5
Chloroethane	6/20/94	10	U	-		9.29	U	9.29	U	9.29	U	9.29	U	9.29	U	10	U	56		10	U	10	U	11		-		-		CLP/LLRA	-	-
	9/27/94	18		-		10	U	10	U	10	U	10	U	10	U	-		-		-		-		-		13		10	U	CLP	-	-
	2/06/95	10	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	10	U	26		10	U	2	J	7	J	6	J	-		CLP/LLRA	-	-
	4/11/95	10	U	10	U	10	U	10	U	10	U	10	U	10	U	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLP	-	-
Dichlorodifluoromethane	6/20/94	10	U	-		46.64	U	46.64	U	46.64	U	46.64	U	46.64	U	10	U	4	J	10	U	10	U	10	U	-		-		CLP/LLRA	0.19	-
	9/27/94	10	U	-		10	U	10	U	10	U	10	U	10	U	-		-		-		-		-		10	U	10	U	CLP	0.19	-
	2/06/95	10	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	10	U	10	U	10	U	10	U	10	U	10	U	-		CLP/LLRA	0.19	-
	4/11/95	10	U	10	U	10	U	10	UJ	10	UJ	10	UJ	10	UJ	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLP	0.19	-
1,1-Dichloroethane	6/20/94	10	U	-		0.99	J	43.10	U	0.26	J	43.10	U	43.10	U	1	J	23		10	U	59		2	J	-		-		CLP/LLRA	700**	-
	9/27/94	10	U	-		10	U	10	U	10	U	10	U	10	U	-		-		-		-		-		10	U	10	U	CLP	700**	-
	2/06/95	10	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	10	U	10	U	10	U	45		10	U	10	U	-		CLP/LLRA	700**	-
	4/11/95	10	U	10	U	10	U	10	U	10	U	10	U	10	U	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLP	700**	-
1,1-Dichloroethene	6/20/94	10	U	-		9.75	U	9.75	U	9.75	U	9.75	U	9.75	U	10	U	10	U	10	U	10	U	10	U	-		-		CLP/LLRA	7	7
	9/27/94	10	U	-		10	U	10	U	10	U	10	U	10	U	-		-		-		-		-		10	U	10	U	CLP	7	7
	2/06/95	10	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	10	U	10	U	10	U	10	U	10	U	10	U	-		CLP/LLRA	7	7
	4/11/95	10	U	10	U	10	U	10	U	10	U	10	U	10	U	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLP	7	7
cis-1,2-Dichloroethene(3)	6/20/94	10	U	-		9.49	U	9.49	U	9.49	U	9.49	U	9.49	U	10	U	4	J	10	U	58		10	U	-		-		CLP/LLRA	70	70
	9/27/94	10	U	-		10	U	10	U	10	U	10	U	10	U	-		-		-		-		-		10	U	10	U	CLP	70	70
	2/06/95	10	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	10	U	10	U	10	U	42		10	U	10	U	-		CLP/LLRA	70	70
	4/11/95	10	U	10	U	10	U	10	U	10	U	10	U	10	U	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLP	70	70
trans-1,3-Dichloropropene	6/20/94	10	U	-		24.49	U	24.49	U	24.49	U	24.49	U	24.49	U	10	U	10	U	10	U	10	U	10	U	-		-		CLP/LLRA	-	-
	9/27/94	10	U	-		10	U	10	U	10	U	10	U	10	U	-		-		-		-		-		10	U	10	U	CLP	-	-
	2/06/95	10	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	10	U	10	U	10	U	10	U	10	U	10	U	-		CLP/LLRA	-	-
	4/11/95	10	U	10	U	10	U	10	U	10	U	10	U	10	U	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLP	-	-
Methylene Chloride	6/20/94	10	U	-		36.20	UJ	36.20	UJ	36.20	UJ	36.20	UJ	36.20	U	6	[illegible]	9	[illegible]	3	J	1	J	8	J	-		-		CLP/LLRA	5	5
	9/27/94	13	U	-		10	U	10	U	10	U	32		37		-		-		-		-		-		10	U	10	U	CLP	5	5
	2/06/95	10	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	10	U	2	J	3	J	1	J	10	U	10	U	-		CLP/LLRA	5	5
	4/11/95	10	U	10	U	10	U	10	U	10	U	10	U	10	U	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLP	5	5
Tetrachloroethene	6/20/94	10	U	-		7.84	U	0.24	J	7.84	U	7.84	U	7.84	U	10	U	10	U	10	U	18		10	U	-		-		CLP/LLRA	0.7	5
	9/27/94	10	U	-		10	U	10	U	10	U	10	U	10	U	-		-		-		-		-		10	U	10	U	CLP	0.7	5
	2/06/95	10	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	10	U	10	U	10	U	12		10	U	10	U	-		CLP/LLRA	0.7	5
	4/11/95	10	U	10	U	10	U	10	U	10	U	10	U	10	U	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLP	0.7	5
Trichloroethene	6/20/94	10	U	-		21.20	U	21.20	U	21.20	U	21.20	U	21.20	U	10	U	1	J	10	U	13		10	U	-		-		CLP/LLRA	2.8	5
	9/27/94	10	U	-		10	U	10	U	10	U	10	U	10	U	-		-		-		-		-		10	U	10	U	CLP	2.8	5
	2/06/95	10	U	2.5	U	2.5	U	2.5	U	2.5	U	2.5	U	2.5	U	10	U	10	U	10	U	8	J	10	U	10	U	-		CLP/LLRA	2.8	5
	4/11/95	10	U	10	U	10	U	10	U	10	U	10	U	10	U	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLP	2.8	5
1,1,1-Trichloroethane	6/20/94	10	U	-		30.11	U	30.11	U	0.08	J	30.11	U	30.11	U	10	U	2	J	10	U	3	J	10	U	-		-		CLP/LLRA	200	200
	9/27/94	10	U	-		10	U	10	U	5	J	10	U	10	U	-		-		-		-		-		10	U	10	U	CLP	200	200
	2/06/95	10	U	1.0	U	1.0	U	1.0	U	2.5		1.0	U	1.0	U	10	U	10	U	10	U	2	J	10	U	10	U	-		CLP/LLRA	200	200
	4/11/95	10	U	10	U	10	U	1	J	3	J	10	U	10	U	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLP	200	200
Vinyl Chloride	6/20/94	10	U	-		6.60	UJ	6.60	UJ	6.60	UJ	6.60	UJ	6.60	U	10	U	10	U	10	U	10	U	10	U	-		-		CLP/LLRA	0.015	2
	9/27/94	10	U	-		10	U	10	U	10	U	10	U	10	U	-		-		-		-		-		10	U	10	U	CLP	0.015	2
	2/06/95	10	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	10	U	10	U	10	U	2	J	10	U	10	U	-		CLP/LLRA	0.015	2
	4/11/95	10	UJ	10	U	10	U	10	UJ	10	UJ	10	UJ	10	UJ	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CLP	0.015	2

NOTES:
NCS Denotes North Carolina Groundwater Quality Standard (T15A: 02L .0200)
MCL Denotes EPA Maximum Contaminant Level (EPA 822-R-94-001)
U Denotes not detected above Instrument Detection Level(IDL) for Inorganics and not detected above CRQL for Organics (CLP SOW Only).
J Denotes an estimated value
CRQL Contract Required Quantification Limit
\- Denotes Not Avaliable or Not Sampled
Shading - denotes parameter results that exceed U.S. EPA Maximum Contaminant Levels.

Note:
1) CLP analytical methods utilize CLP Statement of Work OLMO1.9(3/90) for organic analysis
2) LLRA analytical methods utilize EPA SW-846 Method #8021
3)For CLP, 1,2-Dichloroethene was reported as total concentration; for LLRA concentration was reported for cis-isomer.
4)For the 6/20/94 and 2/6/95 events, boundary monitoring well analyses were performed by using LLRA analytical methods and surface water sampling locations analyses were performed by using CLP analytical methods.

H/Eteam/6520-21/Table5B.xls

Watauga County Landfill
Watauga County, North Carolina
Upgradient Well: MW-1
11/24/95

Table 5C
Background Assessment Metal Target Parameter Analytical Results
Core Groundwater Monitoring Wells and Septic Field Monitoring Wells

Parameter	Event	Results ug/l(ppb)																												
		MW-1		MW-2		MW-3		MW-4		MW-6		MW-8		MW-9		MW-10		MW-11		MW-12		MW-17		SFW-1		SFW-2		SFW-3		Analysis Type	NCS (ug/L)	MCL (ug/L)
		METALS, TOTAL																														
Barium, Total	6/20/94	203		199		123		24.2		652		281		710		109		117		101		117		-		-		-		CLP	2000	2000
	9/27/94	149		204		119		23.5		502		86.9		632		113		153		101		90.4		-		-		-		CLP	2000	2000
	2/06/95	157		192		109		27.2		418		70.4		615		94.8		176		104		87.2		69.7	J	1050	J	143	J	CLP	2000	2000
	4/11/95	143		212	J	82		23.2	J	477		65		628	J	93.1		295		97.7	J	77.3		-		-		-		CLP	2000	2000
Iron, Total	6/20/94	409		24.4	U	9950		24.4	U	24900		16100	J	7060		5460		337	J	1800	J	3220		-		-		-		CLP	300	300*
	9/27/94	1390		140		9320		71.8		9170		418		42		3100		3.8	U	16		149		-		-		-		CLP	300	300*
	2/06/95	2830		46		6610		552		5930		368		735		2240		296		61.3		260		123	J	56600	J	7240	J	CLP	300	300*
	4/11/95	2490	J	245	J	3600	J	54.4	UJ	8300	J	149	J	81.7	UJ	234	J	15.7	U	54.4	UJ	63.7	J	-		-		-		CLP	300*	300*
Cadmium, Total	6/20/94	6.0		4.5	UJ	5.5		4.5	UJ	4.5	UJ	4.6	UJ	4.5	UJ	4.5	UJ	4.6	UJ	4.6	UJ	4.5	UJ	-		-		-		CLP	5	5
	9/27/94	4.3	U	4.6	U	4.6	U	4.6	U	4.3	U	4.3	U	4.6	U	4.6	U	4.3	U	4.6	U	4.6	U	-		-		-		CLP	5	5
	2/06/95	0.5	U	4.4	U	4.4	U	4.4	U	4.4	U	4.4	U	4.4	U	4.4	U	4.4	U	4.4	U	4.4	U	4.4	U	4.4	U	4.4	U	CLP	5	5
	4/11/95	0.3	U	4.4	UJ	0.3	U	4.4	UJ	0.3	U	0.3	U	4.4	UJ	0.3	U	0.3	U	4.4	UJ	0.3	U	-		-		-		CLP	5	5
Mercury, Total	6/20/94	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	-		-		-		CLP	1.1	2
	9/27/94	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	-		-		-		CLP	1.1	2
	2/06/95	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	CLP	1.1	2
	4/11/95	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	-		-		-		CLP	1.1	2

Boundary Groundwater Monitoring Wells and Surface Water Sampling Locations

Parameter	Event	Results ug/l(ppb)																												
		MW-5		MW-7		MW-13		MW-14		MW-15		MW-16		MW-18		S1		S2		S3		S4		S5		L1		Mt. Spring		Analysis Type	NCS (ug/L)	MCL (ug/L)
		METALS, TOTAL																														
Barium, Total	6/20/94	-		439		54.2		18.4		94.9		66.8		73.6		133		755		366		94.1		197		-		-		CLP	2000	2000
	9/27/94	-		698		59.7		17.4		79		70.6		78.7		-		-		-		-		-		-		5.5		CLP	2000	2000
	2/06/95	710		743		79.4		16.3		82.3		72.5		67.9		86.8	J	350	J	235	J	82.5	J	472	J	2240	J	-		CLP	2000	2000
	4/11/95	591		426		54.4		16.4	J	78.4	J	70.3	J	83	J	-	-	-	-	-	-	-	-	-	-	-	-	-		CLP	2000	2000
Iron, Total	6/20/94	-		15200		283		100	U	2110		78.6		24.4		11300		30800		8600		1040		26400		-		-		CLP	300	300*
	9/27/94	-		19200		450		3.8		554		117		12.2		-		-		-		-		-		-		31.4		CLP	300	300*
	2/06/95	475		26400		2370		61.3		975		490		61.3		13200	J	42000	J	8790	J	3110	J	90300	J	255000	J	-		CLP	300	300*
	4/11/95	15.7	U	5180	J	131	J	40.8	UJ	490	J	331	J	40.8	UJ	-	-	-	-	-	-	-	-	-	-	-	-	-		CLP	300*	300*
Cadmium, Total	6/20/94	-		4.5	UJ	4.5	UJ	4.5	UJ	4.5	UJ	4.5	UJ	4.5	UJ	4.5	U	4.5	U	4.5	U	4.5	U	4.5	U	-		-		CLP	5	5
	9/27/94	-		4.3	U	4.3	U	4.3	U	4.6	U	4.6	U	4.6	U	-		-		-		-		-		-		4.3	U	CLP	5	5
	2/06/95	4.4	U	4.4	U	4.4	U	4.4	U	4.4	U	4.4	U	4.4	U	4.4	U	4.4	U	4.4	U	4.4	U	4.4	U	4.4	U	-		CLP	5	5
	4/11/95	0.3	U	[illegible]		0.3	U	4.4	UJ	4.4	UJ	4.4	UJ	4.4	UJ	-	-	-	-	-	-	-	-	-	-	-	-	-		CLP	5	5
Mercury, Total	6/20/94	-		0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2		0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	-		-		CLP	1.1	2
	9/27/94	-		0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	-		-		-		-		-		-		0.2	U	CLP	1.1	2
	2/06/95	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	-		CLP	1.1	2
	4/11/95	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	-	-	-	-	-	-	-	-	-	-	-	-	-		CLP	1.1	2

Notes:

NCS Denotes North Carolina Groundwater Quality Standard (T15A: 02L .0200)
MCL Denotes EPA Maximum Contaminant Level (EPA 822-R-94-001)
U Denotes not detected above Instrument Detection Limit(IDL) for Inorganics(CLP SOW only)
J Denotes an estimated value
* Denotes a Secondary Maximum Contaminant Level (SMCL) for Total Iron
** Denotes a proposed NCS
\- Denotes Not Avaliable or Not S mpled
Shading denotes parameter results that exceed U.S. EPA Maximum Contaminant Levels.
CLP analytical methods utilize relevant Atomic Adsorption technique and Inductively Coupled Plasma (ICP) method,
in accordance with EPA Contract Laboratory Program (CLP) Statement of Work ILMO 3.0 for metal analysis.

Watauga County Landfill
Watauga County, North Carolina
Upgradient Well: MW-1
12/07/95

Table 6A

Cumulative Detected Non-Target Organic Parameter Analytical Results
Contract Laboratory Program (CLP) Statement of Work (SOW) - Organics

Parameter	Event	Results ug/L(ppb)																								NCS (ug/L)	MCL (ug/L)
		MW-1		MW-3		MW-4		MW-7		MW-8		MW-9		MW-10		MW-11		MW-12		MW-17		S1		S2			
Acetone	6/20/94	61		~		~		-		-		-		-		~		-		-		~		~		700	-
	9/27/94	~		~		~		~		~		~		40	J	~		~		~		~		-		700	-
	4/11/95	~		~		~		15	J	~		~		~		~		~		~		~		-		700	-
2-Butanone	9/27/94	~		~		~		19		~		~		~		~		~		~		~		-		-	-
	7/10/95	~		~		~		~		~		~		~		~		~		~		~		5	J	-	-
Carbon Tetrachloride	4/11/95	~		~		2	J	~		~		~		~		~		1	J	2	J	~		-		0.3	5
1,2-Dichloropropane	4/11/95	~		~		~		~		1	J	~		~		~		~		2	J	~		-		0.56	5
	2/6/95	~		1	J	~		~		1	J	~		~		~		~		1	J	~		-		0.56	5
2-methyl-2-pentanone	6/20/94	24		~		~		-		-		-		-		~		-		-		~		6		-	-
1,1,2,2-Tetrachloroethane	6/20/94	2	J	~		~		-		-		-		-		~		-		-		~		-		-	-
Ethylbenzene	6/20/94	10		~		~		-		-		-		-		~		-		-		~		6		29	700
	7/10/95	~		~		~		-		-		-		-		~		-		-		~		3	J	29	700
Toluene	6/20/94	2	J	~		~		-		-		-		-		~		-		-		~		7		1000	1000
	4/11/95	~		~		2	J	~		~		~		~		~		1	J	4	J	~		-		1000	1000
	7/10/95	~		~		~		~		~		~		~		~		~		~		~		2	J	1000	1000
Xylene (total)	6/20/94	64		~		~		-		-		-		-		~		-		-		~		20		530	10000
	9/27/94	~		~		~		1	J	~		3	J	~		~		~		~		~		~		530	10000
	4/11/95	~		~		~		~		~		3	J	~		~		~		~		~		~		530	10000
	7/10/95																					~		6	J	530	10000
m/p Xylene	7/10/95	~		~		~		~		~		~		~		~		~		~		1	J	~		530	10000

Tentatively Identified Compounds

Parameter	Event	Results ug/L(ppb)											
		MW-6		MW-9		MW-11		MW-16		MW-17		MW-18	
Hexane	4/11/95	~		~		~		7	NJ	~		~	
Dichlorofluoromethane	4/11/95	~		200	NJ	~		~		~		~	
Unknown Alkane	4/11/95	~		~		6	NJ	~		~		~	
	4/11/95	~		~		9	NJ	~		~		~	
	4/11/95	~		~		6	NJ	~		~		~	
Unknown Cycloalkane	4/11/95	~		~		12	NJ	~		~		~	
	4/11/95	~		~		28	NJ	~		~		~	
Unknown Hydrocarbon	4/11/95	~		~		10	NJ	10	NJ	7	NJ	7	NJ
	4/11/95	~		~		5	NJ	7	NJ	37	NJ	~	
	4/11/95	~		~		13	NJ	18	NJ	9	NJ	~	
	4/11/95	~		~		~		9	NJ	~		~	
Unknown Unsaturated Hydrocarbon	4/11/95	~		~		7	NJ	~		~		~	
	7/10/95	~		~		~		~		~		~	
Unknown Ketone	4/11/95	50	NJ	~		8	NJ	~		~		~	

Notes:

NCS Denotes North Carolina Groundwater Quality Standard (T15A: 02L .0200)
MCL Denotes EPA Maximum Contaminant Level (EPA 822-R-94-001)
~ Denotes Not Detected
- Denotes Not Available
J Denotes an estimated value
N Denotes tentatively identified
Organic parameters were analyzed in accordance with USEPA CLP SOW OLMO1.9 (3/90).

Watauga County Landfill
Watauga County, North Carolina
Upgradient Well: MW-1
11/27/95

Table 6B
Cumulative Detected Non-Target Organic Parameter Analytical Results
Low Level Risk Assessment (LLRA) Analytical Methods

Parameter	Event	Method	Results ug/L (ppb)																										NCS	MCL
			MW-3		MW-6		MW-7		MW-8		MW-9		MW-10		MW-12		MW-13		MW-14		MW-16		MW-17		MW-18		Trip Blank		(ug/L)	(ug/L)
1,2,3-Trichlorobenzene	6/20/94	8021	~		~		~		~		~		~		0.32	J	0.47	J	~		~		~		~		~		-	-
1,4-Dichlorobenzene	7/10/95	8260	~		~		~		1.1	J	~		~		~		~		~		~		~		~		~		-	100
1,3,5-Trimethylbenzene	6/20/94	8021	~		~		~		~		0.17	J	~		~		~		~		~		~		~		~		-	-
Isopropylbenzene	6/20/94	8021	~		~		~		~		0.41	JB	~		1.06	JB	~		~		1.67	JB	~	JB	0.50	JB	0.36	JB	-	-
n-Propylbenzene	6/20/94	8021	~		~		~		~		0.50	J	~		0.33	J	~		~		0.66	J	~		~		~		-	-
Trichlorofluoromethane	6/20/94	8021	~		~		~		~		20.50	J	~		~		~		~		~		~		~		~		2,100	-
	7/10/95	8260	1.1	J	~		~		~		~		~		~		~		~		~		~		~		~		2100	-
Styrene	6/20/94	8021	~		~		~		~		0.94	J	~		0.65	J	~		~		~		~		~		~		100	100
Napthylene	6/20/94	8021	~		~		0.33	J	~		0.69	J	~		0.74	J	7.07	J	~		0.62	J	~		~		~		-	-
o-Xylene	6/20/94	8021	~		~		0.83	J	~		~		~		~		~		~		~		~		~		~		530	10,000
	2/6/95	8021	~		~		0.6		~		~		~		~		~		~		~		~		~		~		530	10,000
	7/10/95	8260	~		~		~		~		3.0	J	~		~		~		~		~		~		~		~		530	10000
t-bb+tmb+s-bb	6/20/94	8021	~		~		44.97	J	8.91	J	~		~		0.83		~		~		~		~		~		~		-	-
trans-1,2-Dichloroethene	6/20/94	8021	~		~		1.53	J	2.03	J	~		~		1.47	J	~		~		~		1.31		~		~		70	100
	2/6/95	8021	~		~		2.6		~		~		~		~		~		~		~		~		~		~		70	100
	7/10/95	8260	1.6	J	5.7		1.6	J	1.4	J	~		~		~		~		~		~		~		~		~		70	100
1,2,-Dichloroethane	7/10/95	8260	1.8	J	~		~		~		~		~		~		~		~		~		1.8	J	~		~		-	-
	7/10/95	8021	1.8	J	~		~		0.89	J	~		~		~		~		~		~		1.7	J	~		~		-	-
Dibromochloromethane	2/6/95	8021	~		~		~		~		~		~		~		~		0.6	J	~		~		~		~		-	100
Bromomethane	2/6/95	8021	~		~		5.8		~		~		~		~		~		~		~		~		~		~		0.30	-
	7/10/95	8260	2.4	J	~		~		~		~		~		~		~		~		~		~		~		~		0.30	-
1,2-Dichloropropane	2/6/95	8021	~		~		1.6	J	~		~		~		~		~		~		~		~		~		~		0.56	5
	7/10/95	8260	1	J	1	J	1.6	J	~		~		~		~		~		~		~		~		~		~		0.56	5
	7/10/95	8021	~		~		1.4	J	0.87	J	~		~		~		~		~		~		0.80		~		~		0.56	5
2-Butanone	7/10/95	8021	~		~		15		4.9	J	~		3.1	J	~		~		~		~		~		~		~		-	-

Notes:
NCS Denotes North Carolina Groundwater Quality Standard (T15A: 02L .0200)
MCL Denotes EPA Maximum Contaminant Level (EPA 822-R-94-001)
~ Denotes not detected
- Denotes Not Available
J Denotes an estimated value
B Denotes present in blank
Shading Denotes Parameter results that meet or exceed U.S. EPA Maximum Contaminant Levels
t-bb+tmb+s-bb: tert-Butylbenzene + 1,2,4-Trimethylbenzene + sec-Butylbenzene

H:6520-21\TABLE6B.xls

Drawing Under Seperate Cover

APPENDIX II

POTABLE WELL TESTING ANALYTICAL RESULTS

POTABLE WELL TESTING - WATAUGA COUNTY, NC
RESULTS OF VOLATILE AND SEMI-VOLATILE ANALYSIS

CONSTITUENT	MARCH 5, 1993*	MARCH 18, 1993*	MARCH 24, 1993*	JUNE 23, 1993**	JULY 13, 1994**	NCS	MCL
Carroll Residence (12)							
Benzene	2.1	1.7	NS	1.9	NS	1.0	5
Chloroethane	173.4	74.5		ND		---	---
Chloromethane	ND	14.8		ND		---	---
Dichlorodifluoromethane	30.6	ND		ND		0.19	---
1,1-Dichloroethane	20.9	17.4		ND		700	---
1,1-Dichloroethene	4.1	1.5		ND		7	7
cis-1,2-Dichloroethene#	1.2	0.9		<1.0		70	70
2,2-Dichloropropane#	1.2	0.9		ND		---	---
4-Isopropyltoluene	ND	0.2		ND		---	---
Isopropylbenzene	0.6	ND		ND		---	---
Methylene Chloride	ND	43.0(XT)		138.2		5	5
Styrene	2.8	0.5		ND		0.014	100
Tert-Butyl Methyl Ether	ND	ND		2.4		200	---
Tetrachloroethene	5.4(X)	4.7		4.2		0.7	5
Toluene	ND	0.6(T)		ND		1000	1000
1,1,1-Trichloroethane	19.7	15.7		29.4		200	200
Trichloroethene	7.0(X)	5.5(X)		7.0		2.8	5
Trichlorofluoromethane	37.1	20.2		ND		2100	---
Vinyl Chloride	1.7(T)	ND		ND		0.015	2
p and m-Xylene	ND	ND		<1.0		400	10,000
o-Xylene	ND	3.4		2.9		400	10,000
Nissan-Mazda Dealership (4)							
Carbon Tetrachloride	0.2	NS	ND	NS	ND	0.3	5
Chloroethane	19.1		ND		ND	---	---
Dichlorodifluoromethane	8.2		8.7		ND	0.19	---
1,1-Dichloroethane	98.5		63.1		104.3	700	---
1,2-Dichloroethane	ND		0.5		ND	0.38	---
1,1-Dichloroethene	5.4		3.7		4.7	7	7
cis-1,2-Dichloroethene#	22.2		13.0		23.7	70	70
1,2-Dichloropropane	0.5		0.3		ND	0.56	5
2,2-Dichloropropane#	22.2		13.0		ND	---	---
Tetrachloroethene	21.8(X)		28.1(X)		30.9	0.7	5
Toluene	ND		0.8(T)		ND	1000	1000
1,1,1-Trichloroethane	14.7		19.3		22.9	200	200
Trichloroethene	11.2(X)		9.1(X)		12.6	2.8	5
Trichlorofluoromethane	0.4		ND		ND	2100	---
o-Xylene	0.4		0.5(T)		ND	400	10,000

NOTE: All Concentrations are in ppb (ug/L).

(Other footnotes located on page 4)

POTABLE WELL TESTING - WATAUGA COUNTY, NC
RESULTS OF VOLATILE AND SEMI-VOLATILE ANALYSIS

CONSTITUENT	3/5/93*	3/18/93*	5/11/93**	6/23/93**	3/30/94**	4/6/94**	8/2/94**	12/7/94**	4/26/95**	10/24/95	NCS	MCL
Blue Ridge Electric Membership Company - (BREMCO) (5)												
1,1-Dichloroethane	0.7					<1.0	1.4	1.0	1.2	1.8	700	---
Naphthalene	0.6					ND	ND	ND	ND	ND	---	---
1,1,1-Trichlorothane	0.2					<1.0	<1.0	<1.0	<1.0	<1.0	200	200
Trichloroethene	0.5	NS	NS	NS	NS	<1.0	<1.0	<1.0	<1.0	<1.0	2.8	5
1,1-Dichloroethene	ND					1.0	1.9	<1.0	1.1	1.7	7	7
cis-1,2-Trichloroethen	ND					<1.0	ND	<1.0	<1.0	<1.0	70	70
Tetrachloroethene	ND					<1.0	<1.0	trace	<1.0	<1.0	0.7	5
Bolick rental resident (2)												
tert-Butylbenzene	1.1					ND				ND	---	---
Isopropylbenzene	0.7					ND				ND	---	---
Trichloroethene	0.5					ND				ND	2.8	5
1,3,5-Trimethylbenzen	0.7	NS	NS	NS	NS	ND	NS	NS		ND	---	---
1,1-Dichloroethane	ND					trace			NS	<1.0	700	---
1,1-Dichloroethene	ND					trace				trace	7	7
Methyl Ethyl Ketone	ND					trace				35.3	170	---
Tetrahydrofuran	ND					ND				42.3	---	---
Perry Residence (11)												
Dichlorodifluromethan	2.5				ND						0.19	---
Naphthalene	0.7				ND						---	---
Chloromethane	<9	NS	NS	ND	ND	NS	NS	NS	NS	NS	---	---
Methylene Chloride	<0.6				ND						5	5
Chloroform					<1.0						0.19	100
Greer residence (15)												
Benzene						<1.0					1.0	5
Toluene						6.4					1000	1000
Tetrachloroethene	NS	ND	NS	NS	NS	trace	NS	ND	NS	NS	0.7	5
Ethylbenzene						trace					29	700
p and m - Xylene						<1.0					400	10,000
Styrene						trace					0.14	100
Ward residence (24)												
Methylene Chloride			3.2	ND	ND			ND	ND	ND	5	5
1,1,1-Trichloroethane			<1.0	<1.0	<1.0			ND	ND	ND	200	200
Trichloroethene			trace	trace	<1.0			trace	ND	ND	2.8	5
Tetrachloroethene	NS	NS	ND	trace	<1.0	NS	ND	trace	trace	<1.0	0.7	5
Carbon Tetrachloride			ND	ND	<1.0			ND	ND	ND	0.3	5
1,1-Dichloroethane			ND	ND	<1.0			<1.0	<1.0	trace	700	---
Chloroform			ND	ND	trace			ND	trace	trace	0.19	100
1,2-Dibromoethane (EDB)			ND	ND	ND			ND	ND	trace	0.0004	0.05

NOTE: All Concentrations are in ppb (ug/L). (Other footnotes located on page 4)

RESULTS OF VOLATILE AND SEMI-VOLATILE ANALYSIS

CONSTITUENT	3/18/93*	5/11/93**	9/21/93**	3/30/94**	1/12/95**	10/24/95**	NCS	MCL
Shared Well #1 (8 Houses) (13)								
sec-Butylbenzene	0.2						---	---
Carbon Tetrachloride	0.1						0.3	5
Methylene Chloride	1.5	ND	ND	NS	NS	NS	5	5
alpha-Chlordane	0.4						0.27	2
gamma-Chlordane	0.3						0.27	2
Shared Well #2 (4 Houses) (14)								
1,4-Dichlorobenzene	0.5			ND	ND	ND	---	---
1,1-Dichloroethane	ND			ND	ND	<1.0	700	---
1,1-Dichloroethene	ND			<1.0	<1.0	ND	7	7
Tetrachloroethene	ND			ND	ND	trace	0.7	5
1,1,1-Trichoroethane	ND	NS	NS	<1.0	ND	trace	200	200
Chloroform	ND			trace	ND	9.0	0.19	100
Bromodichloromethane	ND			ND	ND	1.4	---	100
Dibromochloromethane	ND			ND	ND	<1.0	---	---
2-Chlorotoluene	ND			ND	ND	1.2	---	---
4-Chlorotoluene	ND			ND	ND	1.0	---	---
Methyl Ethyl Ketone	ND			ND	ND	24.6	170	---
Tetrahydrofuran	ND			ND	ND	13.4	---	---

CONSTITUENT	3/5/93	4/26/93	NCS	MCL
Chevrolet dealership (7)				
t-butyl methyl ether	ND	24.4	200	---

CONSTITUENT	3/23/93**	3/23/93**	5/11/93**	6/23/93**	8/3/93**	8/9/93**	10/20/93**	3/30/94**	9/21/94**	1/12/95**	4/26/95**	NCS	MCL
Simko residence (20)													
1,1,1-Trichloroethane		trace										---	200
Chloroform		<1.0	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.19	100
Johnson residence (23)													
Chloroform	NS	NS	trace	NS	NS	NS	NS	NS	NS	NS	NS	0.19	100
McLean residence (26)													
Chloroform	NS	NS	NS	<1.0	NS	NS	NS	NS	NS	NS	NS	1.0	100
Yates residence (30)													
Chloroform	NS	NS	NS	NS	<1.0	NS	NS	NS	NS	NS	NS	0.19	100
McClintock residence (33)													
1,2-Dichloroethane	NS	NS	NS	NS	NS	<1.0	<1.0	NS	ND	NS	NS	700	---
Chloroform						<1.0	ND		<1.0			0.19	100
Welch residence; Meadowview condominiums (38)													
Chloroform	NS	NS	NS	NS	NS	NS	<1.0	NS	NS	NS	NS	0.19	100
Austin residence (40)													
Chloroform	NS	NS	NS	NS	NS	NS	NS	NS	NS	trace	NS	0.19	100

NOTE: All Concentrations are in ppb (ug/L)

(Other footnotes located on page 4)

POTABLE WELL TESTING - WATAUGA COUNTY, NC
WELLS SHOWING NO DETECTED ORGANIC COMPOUNDS

SAMPLING LOCATION	SAMPLING DATES
Colene Bolick residence (1)	March 5, 1993*
Roten residence (3)	March 5, 1993* and July 3, 1994**
Hollar and Green Produce (6)	March 5, 1993*
Vannoy residence (8)	March 5, 1993*
Martin High County Rentals #1 (9)	March 5, 1993*
Martin High Country Rentals #2 (10)	March 5, 1993*
Williamson residence (16)	March 18, 1993*
Suddreth residence (17)	March 18, 1993*, September 21, 1993**, and July 3, 1994**
Taylor residence (18)	March 18, 1993*
Hodges residence (19)	March 18, 1993*
Findt residence (21)	March 18, 1993*
Rusher residence (22)	March 23, 1993**
Younce residence (25)	May 11, 1993**
Medlin residence (27)	June 23, 1993**
Rector residence (28)	June 23, 1993**
Robinson residence (29)	June 23, 1993**
Cook residence (31)	August 3, 1993**
Animal Control Office (32)	August 3, 1993**
Brook Hollow Trailer Park (37)	October 11, 1993**
Green residence (34)	October 20, 1993**
Shared well #3 (35)	October 20, 1993**
BREMCO residence (36)	September 21, 1993**
Isaacs residence (39)	November 16, 1994**
Norris residence (41)	January 12, 1995**

TABLE 5A AND 5B NOTES:

The sampled well reference number as presented on the Vicinity Map (Figure 3) is denoted in parentheses following the sampling locations name

* Laboratory analysis performed by Central Virginia Laboratories and Constultants (CVLC) utilizing EPA Methods 502.2 (Volatiles) and 525.1 (Semi-Volatiles)

**Laboratory Analysis performed by NCDEHNR Division of Laboratory Services utilizing EPA Method 502.2 (Volatiles)

\# denotes compound co-elutes

ND denotes no compounds detected for entire analytical scan

NS denotes not sampled on that date

NA denotes compound not analyzed on that date

(T) denotes found in Trip Blank

(E) denotes estimated result

(X) denotes above MCL

NSC-North Carolina Water Qualtiy Standard (DEHNR-15A NCAC 2L.0202)

MCL-EPA Primary Drinking Water Standard Maximum Contaminant Level

APPENDIX III

EPA PRESUMPTIVE REMEDY DIRECTIVE (No. 9355.0-49FS)

United States Environmental Protection Agency

Office of Solid Waste and Emergency Response

Directive No. 9355.0-49FS
EPA 540-F-93-035
PB 93-963339
September 1993

EPA

Presumptive Remedy for CERCLA Municipal Landfill Sites

Office of Emergency and Remedial Response
Hazardous Site Control Division 5203G

Quick Reference Fact Sheet

Since Superfund's inception in 1980, the remedial and removal programs have found that certain categories of sites have similar characteristics, such as types of contaminants present, types of disposal practices, or how environmental media are affected. Based on information acquired from evaluating and cleaning up these sites, the Superfund program is undertaking an initiative to develop presumptive remedies to accelerate future cleanups at these types of sites. The presumptive remedy approach is one tool of acceleration within the Superfund Accelerated Cleanup Model (SACM).

Presumptive remedies are preferred technologies for common categories of sites, based on historical patterns of remedy selection and EPA's scientific and engineering evaluation of performance data on technology implementation. The objective of the presumptive remedies initiative is to use the program's past experience to streamline site investigation and speed up selection of cleanup actions. Over time presumptive remedies are expected to ensure consistency in remedy selection and reduce the cost and time required to clean up similar types of sites. Presumptive remedies are expected to be used at all appropriate sites except under unusual site-specific circumstances.

This directive establishes containment as the presumptive remedy for CERCLA municipal landfills. The framework for the presumptive remedy for these sites is presented in a streamlining manual entitled *Conducting Remedial Investigations/Feasibility Studies for CERCLA Municipal Landfill Sites*, February 1991 (OSWER Directive 9355. 3-11). This directive highlights and emphasizes the importance of certain streamlining principles related to the scoping (planning) stages of the remedial investigation/feasibility study (RI/FS) that were identified in the manual. The directive also provides clarification of and additional guidance in the following areas: (1) the level of detail appropriate for risk assessment of source areas at municipal landfills and (2) the characterization of hot spots.

BACKGROUND

Superfund has conducted pilot projects at four municipal landfill sites[1] on the National Priorities List (NPL) to evaluate the effectiveness of the manual *Conducting Remedial Investigations/Feasibility Studies for CERCLA Municipal Landfill Sites* (hereafter referred to as "the manual") as a streamlining tool and as the framework for the municipal landfill presumptive remedy. Consistent with the National Oil and Hazardous Substances Pollution Contingency Plan (or NCP), EPA's expectation was that containment technologies generally would be appropriate for municipal landfill waste because the volume and heterogeneity of the waste generally make treatment impracticable. The results of the pilots support this expectation and demonstrate that the manual is an effective tool for streamlining the RI/FS process for municipal landfills.

Since the manual's development, the expectation to contain wastes at municipal landfills has evolved into a presumptive remedy for these sites.[2] Implementation of the streamlining principles outlined in the manual at the four pilot sites helped to highlight issues requiring further clarification, such as the degree to which risk assessments can be streamlined for source areas and the characterization and remediation of hot spots. The pilots also demonstrated the value of focusing streamlining efforts at the scoping stage, recognizing that the biggest savings in time and money can be realized if streamlining is incorporated at the beginning of the RI/FS process. Accordingly, this directive addresses those issues identified during the pilots and highlights streamlining opportunities to be considered during the scoping component of the RI/FS.

[1] Municipal landfill sites typically contain a combination of principally municipal and to a lesser extent hazardous wastes.

[2] See EPA Publication 9203.1-021, SACM Bulletins, *Presumptive Remedies for Municipal Landfill Sites*, April 1992, Vol. 1, No. 1, and February 1993, Vol. 2, No. 1, and SACM Bulletin *Presumptive Remedies*, August 1992, Vol. 1, No. 3.

Finally, while the primary focus of the municipal landfill manual is on streamlining the RI/FS, Superfund's goal under SACM is to accelerate the entire clean-up process. Other guidance issued under the municipal landfill presumptive remedy initiative identifies design data that may be collected during the RI/FS to streamline the overall response process for these sites (see Publication No. 9355.3-18FS; *Presumptive Remedies: CERCLA Landfill Caps Data Collection Guide*, to be published in October 1993).

CONTAINMENT AS A PRESUMPTIVE REMEDY

Section 300.430(a)(iii)(B) of the NCP contains the expectation that engineering controls, such as containment, will be used for waste that poses a relatively low long-term threat or where treatment is impracticable. The preamble to the NCP identifies municipal landfills as a type of site where treatment of the waste may be impracticable because of the size and heterogeneity of the contents (55 FR 8704). Waste in CERCLA landfills usually is present in large volumes and is a heterogeneous mixture of municipal waste frequently co-disposed with industrial and/or hazardous waste. Because treatment usually is impracticable, EPA generally considers containment to be the appropriate response action, or the "presumptive remedy," for the source areas of municipal landfill sites.

The presumptive remedy for CERCLA municipal landfill sites relates primarily to containment of the landfill mass and collection and/or treatment of landfill gas. In addition, measures to control landfill leachate, affected ground water at the perimeter of the landfill, and/or upgradient ground-water that is causing saturation of the landfill mass may be implemented as part of the presumptive remedy.

The presumptive remedy does not address exposure pathways outside the source area (landfill), nor does it include the long-term ground-water response action. Additional RI/FS activities, including a risk assessment, will need to be performed, as appropriate, to address those exposure pathways outside the source area. It is expected that RI/FS activities addressing exposure pathways outside the source generally will be conducted concurrently with the streamlined RI/FS for the landfill source presumptive remedy. A response action for exposure pathways outside the source (if any) may be selected together with the presumptive remedy (thereby developing a comprehensive site response), or as an operable unit separate from the presumptive remedy.

Highlight 1 identifies the components of the presumptive remedy. Response actions selected for individual sites will include only those components that are necessary, based on site-specific conditions.

Highlight 1: Components of the Presumptive Remedy: Source Containment

- Landfill cap;
- Source area ground-water control to contain plume;
- Leachate collection and treatment;
- Landfill gas collection and treatment; and/or
- Institutional controls to supplement engineering controls.

The EPA (or State) site manager will make the initial decision of whether a particular municipal landfill site is suitable for the presumptive remedy or whether a more comprehensive RI/FS is required. Generally, this determination will depend on whether the site is suitable for a streamlined risk evaluation, as described on page 4. The community, state, and potentially responsible parties (PRPs) should be notified that a presumptive remedy is being considered for the site before work on the RI/FS work plan is initiated. The notification may take the form of a fact sheet, a notice in a local newspaper, and/or a public meeting.

Use of the presumptive remedy eliminates the need for the initial identification and screening of alternatives during the feasibility study (FS). Section 300.430(e)(1) of the NCP states that, "... the lead agency shall include an alternatives screening step, <u>when needed</u>, (emphasis added) to select a reasonable number of alternatives for detailed analysis."

EPA conducted an analysis of potentially available technologies for municipal landfills and found that certain technologies are routinely and appropriately screened out on the basis of effectiveness, feasibility, or cost (NCP Section 300.430(e)(7)). (See Appendix A to this directive and "Feasibility Study Analysis for CERCLA Municipal Landfills," September 1993 available at EPA Headquarters and Regional Offices.) Based on this analysis, the universe of alternatives that will be analyzed in detail may be limited to the components of the containment remedy identified in Highlight 1, unless site-specific conditions dictate otherwise or alternatives are considered that were not addressed in the FS analysis. The FS analysis document, together with this directive, must be included in the administrative record for each municipal landfill presumptive remedy site to support elimination of the initial identification and screening of site-specific alternatives. Further detailed and comprehensive supporting materials (e.g., FS reports included in analysis, technical reports) can be provided by Headquarters, as needed.

While the universe of alternatives to address the landfill source will be limited to those components identified in Highlight 1, potential alternatives that may exist for each component or combinations of components may be evaluated in the detailed analysis. For example, one component of the presumptive remedy is source area ground-water control. If appropriate, this component may be accomplished in a number of ways, including pump and treat, slurry walls, etc. These potential alternatives may then be combined with other components of the presumptive remedy to develop a range of containment alternatives suitable for site-specific conditions. Response alternatives must then be evaluated in detail against the nine criteria identified in Section 300.430(e)(g) of the NCP. The detailed analysis will identify site-specific ARARs and develop costs on the basis of the particular size and volume of the landfill.

EARLY ACTION AT MUNICIPAL LANDFILLS

EPA has identified the presumptive remedy site categories as good candidates for early action under SACM. At municipal landfills, the upfront knowledge that the source area will be contained may facilitate such early actions as installation of a landfill cap or a ground-water containment system. Depending on the circumstances, early actions may be accomplished using either removal authority (e.g., non-time-critical removal actions) or remedial authority. In some cases, it may be appropriate for an Engineering Evaluation/Cost Analysis to replace part or all of the RI/FS if the source control component will be a non-time-critical removal action. Some factors may affect whether a specific response action would be better accomplished as a removal or remedial action including the size of the action, the associated state cost share, and/or the scope of O&M. A discussion of these factors is contained in *Early Action and Long-term Action Under SACM - Interim Guidance*, Publication No. 9203.1-05I, December 1992.

SCOPING A STREAMLINED RI/FS UNDER THE PRESUMPTIVE REMEDY FRAMEWORK

The goal of an RI/FS is to provide the information necessary to: (1) adequately characterize the site; (2) define site dynamics; (3) define risks; and (4) develop the response action. As discussed in the following sections, the process for achieving each of these goals can be streamlined for CERCLA municipal landfill sites because of the upfront presumption that landfill contents will be contained. The strategy for streamlining each of these areas should be developed early (i.e., during the scoping phase of the RI/FS).

1. Characterizing the Site

The use of existing data is especially important in conducting a streamlined RI/FS for municipal landfills. Characterization of a landfill's contents is not necessary or appropriate for selecting a response action for these sites except in limited cases; rather, existing data are used to determine whether the containment presumption is appropriate. Subsequent sampling efforts should focus on characterizing areas where contaminant migration is suspected, such as leachate discharge areas or areas where surface water runoff has caused erosion. It is important to note that the decision to characterize hot spots should also be based on existing information, such as reliable anecdotal information, documentation, and/or physical evidence (see page 6).

In those limited cases where no information is available for a site, it may not be advisable to initiate use of the presumptive remedy until some data are collected. For example, if there is extensive migration of contaminants from a site located in an area with several sources, it will be necessary to have some information about the landfill source in order to make an association between on-site and off-site contamination.

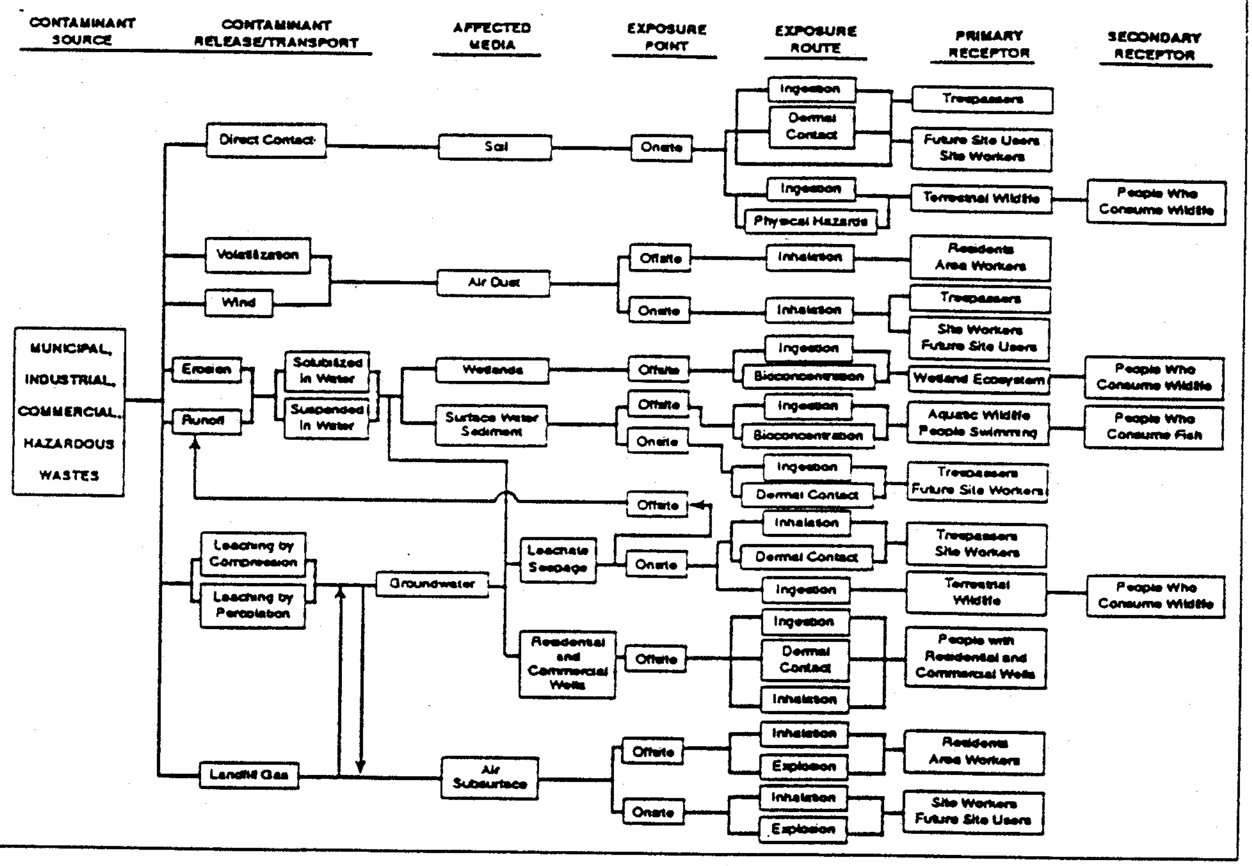
Sources of information of particular interest during scoping include records of previous ownership, state files, closure plans, etc., which may help to determine types and sources of hazardous materials present. In addition, a site visit is appropriate for several reasons, including the verification of existing data, the identification of existing site remediation systems, and to visually characterize wastes (e.g., leachate seeps). Specific information to be collected is provided in Sections 2.1 through 2.4 of the municipal landfill manual.

2. Defining Site Dynamics

The collected data are used to develop a conceptual site model, which is the key component of a streamlined RI/FS. The conceptual site model is an effective tool for defining the site dynamics, streamlining the risk evaluation, and developing the response action. Highlight 2 presents a generic conceptual site model for municipal landfills. The model is developed before any RI field activities are conducted, and its purpose is to aid in understanding and describing the site and to present hypotheses regarding:

- The suspected sources and types of contaminants present;
- Contaminant release and transport mechanisms;

Highlight 2: Generic Conceptual Site Model



- Rate of contaminant release and transport (where possible);
- Affected media;
- Known and potential routes of migration; and
- Known and potential human and environmental receptors.

After the data are evaluated and a site visit is completed, the contaminant release and transport mechanisms relevant to the site should be determined. The key element in developing the conceptual site model is to identify those aspects of the model that require more information to make a decision about response measures. Because containment of the landfill's contents is the presumed response action, the conceptual site model will be of most use in identifying areas beyond the landfill source itself that will require further study, thereby focusing site characterization away from the source area and on areas of potential contaminant migration (e.g., ground water or contaminated sediments).

3. Defining Risks

The municipal landfill manual states that a streamlined or limited baseline risk assessment will be sufficient to initiate response action on the most obvious problems at a municipal landfill (e.g., ground water, leachate, landfill contents, and landfill gas). One method for establishing risk using a streamlined approach is to compare contaminant concentration levels (if available) to standards that are potential chemical-specific applicable or relevant and appropriate requirements (ARARs) for the action. The manual states that where established standards for one or more contaminants in a given medium are clearly exceeded, remedial action generally is warranted.[3]

It is important to note, however, that based on site-specific conditions, an active response is not <u>required</u> if ground-water contaminant concentrations exceed chemical-specific standards but the site risk is within the Agency's acceptable risk range (10^{-4} to 10^{-6}). For example, if it is determined that the release of

[3]See also OSWER Directive 9355.0-30, *Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions*, April 22, 1991, which states that if MCLs or non-zero MCLGs are exceeded, [a response] action generally is warranted.

contaminants from a particular landfill is declining, and concentrations of one or more ground-water contaminants are at or barely exceed chemical-specific standards, the Agency may decide not to implement an active response. Such a decision might be based on the understanding that the landfill is no longer acting as a source of ground-water contamination, and that the landfill does not present an unacceptable risk from any other exposure pathway.

A site generally will not be eligible for a streamlined risk evaluation if ground-water contaminant concentrations do not clearly exceed chemical-specific standards or the Agency's accepted level of risk, or other conditions do not exist that provide a clear justification for action (e.g., direct contact with landfill contents resulting from unstable slopes). Under these circumstances, a quantitative risk assessment that addresses all exposure pathways will be necessary to determine whether action is needed.

Ultimately, it is necessary to demonstrate that the final remedy addresses all pathways and contaminants of concern, not just those that triggered the remedial action. As described in the following sections, the conceptual site model is an effective tool for identifying those pathways and illustrating that they have been addressed by the containment remedy.

Streamlined Risk Evaluation Of The Landfill Source

Experience from the presumptive remedy pilots supports the usefulness of a streamlined risk evaluation to initiate an early response action under certain circumstances. As a matter of policy, for the source area of municipal landfills, a quantitative risk assessment that considers all chemicals, their potential additive effects, etc., is not necessary to establish a basis for action if ground-water data are available to demonstrate that contaminants clearly exceed established standards or if other conditions exist that provide a clear justification for action.

A quantitative risk assessment also is not necessary to evaluate whether the containment remedy addresses all pathways and contaminants of concern associated with the source. Rather, all potential exposure pathways can be identified using the conceptual site model and compared to the pathways addressed by the containment presumptive remedy. Highlight 3 illustrates that the containment remedy addresses all exposure pathways associated with the source at municipal landfill sites.

Finally, a quantitative risk assessment is not required to determine clean-up levels because the type of cap will be determined by closure ARARs, and ground water that is extracted as a component of the presumptive remedy will be required to meet discharge limits, or other standards for its disposal. Calculation of clean-up levels for ground-water contamination that has migrated away from the source will not be accomplished under the presumptive

> **Highlight 3: Source Contaminant Exposure Pathways Addressed by Presumptive Remedy**
>
> 1. Direct contact with soil and/or debris prevented by landfill cap;
> 2. Exposure to contaminated ground water within the landfill area prevented by ground-water control;
> 3. Exposure to contaminated leachate prevented by leachate collection and treatment; and
> 4. Exposure to landfill gas addressed by gas collection and treatment, as appropriate.

remedy, since such contamination will require a conventional investigation and a risk assessment.

Streamlining the risk assessment of the source area eliminates the need for sampling and analysis to support the calculation of current or potential future risk associated with direct contact. It is important to note that because the continued effectiveness of the containment remedy depends on the integrity of the containment system, it is likely that institutional controls will be necessary to restrict future activities at a CERCLA municipal landfill after construction of the cap and associated systems. EPA has thus determined that it is not appropriate or necessary to estimate the risk associated with future residential use of the landfill source, as such use would be incompatible with the need to maintain the integrity of the containment system. (Long-term waste management areas, such as municipal landfills, may be appropriate, however, for recreational or other limited uses on a site-specific basis.) The availability and efficacy of institutional controls should be evaluated in the FS. Decision documents should include measures such as institutional controls to ensure the continued integrity of such containment systems whenever possible.

Areas of Contaminant Migration

Almost every municipal landfill site has some characteristic that may require additional study, such as leachate discharge to a wetland or significant surface water run-off caused by drainage problems. These migration pathways, as well as ground-water contamination that has migrated away from the source, generally will require characterization and a more comprehensive risk assessment to determine whether action is warranted beyond the source area and, if so, the type of action that is appropriate.

While future residential use of the landfill source area itself is not considered appropriate, the land adjacent to landfills is frequently used for residential purposes. Therefore, based on site-specific circumstances, it may be appropriate to consider future residential use for ground water and other exposure pathways when assessing risk from areas of contaminant migration.

4. Developing the Response Action

As a first step in developing containment alternatives, response action objectives should be developed on the basis of the pathways identified for action in the conceptual site model. Typically, the primary response action objectives for municipal landfill sites include:

<u>Presumptive Remedy</u>

- Preventing direct contact with landfill contents;
- Minimizing infiltration and resulting contaminant leaching to ground water;
- Controlling surface water runoff and erosion;
- Collecting and treating contaminated ground water and leachate to contain the contaminant plume and prevent further migration from source area; and
- Controlling and treating landfill gas.

<u>Non-Presumptive Remedy</u>

- Remediating ground water;
- Remediating contaminated surface water and sediments; and
- Remediating contaminated wetland areas.

As discussed in Section 3, "Defining Risks," the containment presumptive remedy accomplishes all but the last three of these objectives by addressing all pathways associated with the source. Therefore, the focus of the RI/FS can be shifted to characterizing the media addressed in the last three objectives (contaminated ground water, surface water and sediments, and wetland areas) and on collecting data to support design of the containment remedy.

Treatment of Hot Spots

The decision to characterize and/or treat hot spots is a site-specific judgement that should be based on the consideration of a standard set of factors. Highlight 4 lists questions that should be answered before making the decision to characterize and/or treat hot spots. The overriding question is whether the combination of the waste's physical and chemical characteristics and volume is such that the integrity of the new containment system will be threatened if the waste is left in place. This question should be answered on the basis of what is <u>known</u> about a site (e.g., from operating records or other reliable information). An answer in the affirmative to all of the questions listed in Highlight 4 would indicate that it is likely that the integrity of the containment system would be threatened, or that excavation and treatment of hot spots would be practicable, and that a significant reduction in risk at the site would occur as a result of treating hot spots. EPA expects that few CERCLA municipal landfills will fall into this category; rather, based on the Agency's experience, the majority of sites are expected to be suitable for containment only, based on the heterogeneity of the waste, the lack of reliable information concerning disposal history, and the problems associated with excavating through refuse.

The volume of industrial and/or hazardous waste co-disposed with municipal waste at CERCLA municipal landfills varies from site to site, as does the amount of information available concerning disposal history. It is impossible to fully characterize, excavate, and/or treat the source area of municipal landfills, so uncertainty about the landfill contents is expected. Uncertainty by itself does not call into question the containment approach. However, containment remedies must be designed to take into account the possibility that hot spots are present in addition to those that have been identified and characterized. The presumptive remedy must be relied upon to contain landfill contents and prevent migration of contaminants. This is accomplished by a combination of measures, such as a landfill cap combined with a leachate collection system. Monitoring will further ensure the continued effectiveness of the remedy.

The following examples illustrate site-specific decision making and show how these factors affect the decision whether to characterize and/or treat hot spots.

Examples of Site-Specific Decision Making Concerning Hot Spot Characterization/ Treatment

<u>Site A</u>

There is anecdotal information that approximately 200 drums of hazardous waste were disposed of at this 70-acre former municipal landfill, but their location and contents are unknown. The remedy includes a landfill cap and ground-water and landfill gas treatment.

A search for and characterization of hot spots is not supported at Site A based on the questions listed in

Highlight 4: Characterization of Hot Spots

If all of the following questions can be answered in the affirmative, it is likely that characterization and/or treatment of hot spots is warranted:

1. Does evidence exist to indicate the presence and approximate location of waste?
2. Is the hot spot known to be principal threat waste?*
3. Is the waste in a discrete, accessible part of the landfill?
4. Is the hot spot known to be large enough that its remediation will reduce the threat posed by the overall site but small enough that it is reasonable to consider removal (e.g., 100,000 cubic yards or less)?

*See *A Guide to Principal Threat and Low Level Threat Wastes*, November 1991, Superfund Publication No. 9380.3-06FS.

Highlight 4: (1) no reliable information exists to indicate the location of the waste; (2) the determination of whether the waste is principal threat waste cannot be made since the physical/chemical characteristics of the wastes are unknown; (3) since the location of the waste is unknown, the determination of whether the waste is in a discrete accessible location cannot be made; (4) in this case, the presence of 200 drums in a 70-acre landfill is not considered to significantly affect the threat posed by the overall site. Rather, the containment system will include measures to ensure its continued effectiveness (e.g., monitoring and/or leachate collection) given the uncertainty associated with the landfill contents and suspected drums.

Site B

Approximately 35,000 drums, many containing hazardous wastes, were disposed of in two drum disposal units at this privately owned 80-acre inactive landfill, which was licensed to receive general refuse. The site is divided into two operable units. The remedy for Operable Unit 1 (OU 1) is incineration of drummed wastes in the two drum disposal units. The remedy for OU 2 consists of treatment of contaminated ground water and leachate and containment of treatment residuals (from OU 1) and remaining landfill contents, including passive gas collection and flaring.

Treatment of landfill contents is supported at Site B because all of the questions in Highlight 4 can be answered in the affirmative: (1) existing evidence from previous investigations and sampling conducted by the state (prior to the RI) indicated the presence and approximate location of wastes; (2) the wastes were considered principal threat wastes because they were liquids and (based on sampling) were believed to contain contaminants of concern; (3) the waste is located in discrete accessible parts of the landfill; and (4) the waste volume is large enough that its remediation will significantly reduce the threat posed by the overall site.

CLOSURE REQUIREMENTS

Subtitle D

In the absence of Federal Subtitle D closure regulations, State Subtitle D closure requirements generally have governed CERCLA response actions at municipal landfills as applicable or relevant and appropriate requirements (ARARs). New Federal Subtitle D closure and post-closure care regulations will be in effect on October 9, 1993 (56 FR 50978 and 40 CFR 258).[4] State closure requirements that are ARARs and that are more stringent than the Federal requirements must be attained or waived.

The new Federal regulations contain requirements related to construction and maintenance of the final cover, and leachate collection, ground-water monitoring, and gas monitoring systems. The final cover regulations will be applicable requirements for landfills that received household waste after October 9, 1991. EPA expects that the final cover requirements will be applicable to few, if any, CERCLA municipal landfills, since the receipt of household wastes ceased at most CERCLA landfills before October 1991. Rather, the substantive requirements of the new Subtitle D regulations generally will be considered relevant and appropriate requirements for CERCLA response actions that occur after the effective date.

Subtitle C

RCRA Subtitle C closure requirements may be applicable or relevant and appropriate in certain circumstances. RCRA Subtitle C is applicable if the landfill received waste that is a listed or characteristic waste under RCRA, and:

1. The waste was disposed of after November 19, 1980 (effective date of RCRA), or

[4] An extension of the effective date has been proposed but not finalized at this time.

2. The new response action constitutes disposal under RCRA (i.e., disposal back into the original landfill).[5]

The decision about whether a Subtitle C closure requirement is relevant and appropriate is based on a variety of factors, including the nature of the waste and its hazardous properties, the date on which it was disposed, and the nature of the requirement itself. For more information on RCRA Subtitle C closure requirements, see *RCRA ARARs: Focus on Closure Requirements*, Directive No. 9234.2-04FS, October 1989.

[5]Note that disposal of only small quantity hazardous waste and household hazardous waste does not make Subtitle C applicable.

Notice:

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APPENDIX A
TECHNICAL BASIS FOR PRESUMPTIVE REMEDIES

This Appendix summarizes the analysis that EPA conducted of feasibility study (FS) and Record of Decision (ROD) data from CERCLA municipal landfill sites which led to the establishment of containment as the presumptive remedy for these sites. The objective of the study was to identify those technologies that are consistently included in the remedies selected, those that are consistently screened out, and to identify the basis for their elimination. Results of this analysis support the decision to eliminate the initial technology identification and screening steps on a site-specific basis for this site type. The technical review found that certain technologies are appropriately screened out based on effectiveness, implementability, or excessive costs.

The methodology for this analysis entailed reviewing the technology identification and screening components of the remedy selection process for a representative sample of municipal landfill sites. The number of times each technology was either screened out or selected in each remedy was compiled. A detailed discussion of the methodology used is provided below.

METHODOLOGY

Identification of Sites for Feasibility Study Analysis

Of the 230 municipal landfill sites on the NPL, 149 sites have had a remedy selected for at least one operable unit. Of the 149 sites, 30 were selected for this study on a random basis, or slightly greater than 20 percent. The sites range in size from 8.5 acres to over 200 acres and are located primarily in Regions 1, 2, 3, and 5. This geographical distribution approximates the distribution of municipal landfills on the NPL.

Technology Screening and Remedial Alternative Analysis

The FS analysis involved a review of the technology identification and screening phase, including any pre-screening steps, followed by a review of the detailed analysis and comparative analysis phases. Information derived from each review was documented on site-specific data collection forms, which are available for evaluation as part of the Administrative Record for this presumptive remedy directive. The review focused on the landfill source contamination only; ground-water technologies and alternatives were not included in the analysis.

For the screening phase, the full range of technologies considered was listed on the data collection forms, along with the key reasons given for eliminating technologies from further consideration. These reasons were categorized according to the screening criteria: cost, effectiveness, or implementability. The frequency with which specific reasons were given for eliminating a technology from further consideration was then tallied and compiled into a screening phase summary table.

For the detailed analysis and comparative analysis, information on the relative performance of each technology/alternative with respect to the seven NCP criteria was documented on the site-specific data collection forms. The advantages and disadvantages associated with each clean-up option were highlighted. In some cases, a technology was combined with one or more technologies into one or more alternatives. The disadvantages of a technology/alternative were then compiled into a detailed analysis/comparative analysis summary table, under the assumption that these disadvantages contributed to non-selection. All summary tables are available for review as part of the Administrative Record.

APPENDIX A
TECHNICAL BASIS FOR PRESUMPTIVE REMEDIES (continued)

RESULTS

The information from the technology screening and remedial alternative analyses is provided in Table 1. It demonstrates that containment (the presumptive remedy), was chosen as a component of the selected remedy at all thirty of the sites analyzed. No other technologies or treatments were consistently selected as a remedy or retained for consideration in a remedial alternative. However, at eight of the thirty sites, there were circumstances where technologies were included in the selected remedy to address a site-specific concern, such as principal threat wastes. These technologies are included in the column entitled "Tech. Not Primary Component of Alternative"[1] in Table 1 and include incineration at two sites, waste removal and off-site disposal at two sites, soil vapor extraction at two sites, and bioreclamation at one site.

Leachate collection and gas collection systems were also tracked as part of the detailed analysis and comparison of remedial alternatives. These types of systems generally were not considered as remediation technologies during the screening phases. At fifteen sites, leachate collection was selected as part of the overall containment remedy. At seventeen sites, gas collection systems were selected as part of the overall containment remedy.

This analysis supports the decision to eliminate the initial technology identification and screening step for municipal landfill sites. On a site-specific basis, consideration of remediation technologies may be retained as needed.

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[1] This column title is used for record-keeping purposes only and is not meant to imply that these treatment technologies are not considered important components of the selected remedies.

TABLE 1 • SUMMARY OF SCREENING AND DETAILED ANALYSIS FOR LANDFILLS [1]

TECHNOLOGY [2]	# FSs Where Technology Considered	# FSs Tech. Passed Screening	# FSs Tech. Screened Out	Tech. Not Primary Component of Alternative	#FSs Where Criterion Contributed To Screening Out [3]: Cost	Effectiveness	Implement	# RODs Tech. Selected	# RODs Tech. Not Selected	# RODs Where Criterion Contributed to Non-Selection: Protect	ARARs	TMV Through Treatment	Long-term Effect.	Short-term Effect.	Cost	Implem.	State Concerns [4]	Community Concerns [4]
Multi-layer Cap	28	25	3	0	2	2	0	18	7	1	0	0	1	3	5	3	--	--
Clay Cap	16	8	8	0	1	8	0	4	4	2	2	1	2	1	0	1	--	--
Asphalt Cap	17	0	17	0	2	14	5	0	0	0	0	0	0	0	0	0	--	--
Concrete Cap	17	0	17	0	3	14	5	0	0	0	0	0	0	0	0	0	--	--
Soil Cover	16	7	5	4	0	5	1	5	2	1	0	0	0	0	0	0	--	--
Synthetic Cap	13	3	10	0	0	10	1	2	1	1	1	1	1	1	1	1	--	--
Chemical Seal	5	0	5	0	0	4	0	0	0	0	0	0	0	0	0	0	--	--
Slurry Wall	22	5	14	3	2	8	6	2	3	3	2	2	1	2	0	2	--	--
Grout Curtain	18	0	18	0	3	15	9	0	0	0	0	0	0	0	0	0	--	--
Sheet Piling	17	1	16	0	0	13	5	0	1	0	0	0	0	0	0	0	--	--
Grout Injection	8	0	8	0	0	8	2	0	0	0	0	0	0	0	0	0	--	--
Block Displacement	5	0	5	0	0	3	3	0	0	0	0	0	0	0	0	0	--	--
Bottom Sealing	5	0	5	0	0	3	4	0	0	0	0	0	0	0	0	0	--	--

TABLE 1 • SUMMARY OF SCREENING AND DETAILED ANALYSIS FOR LANDFILLS (Continued) [1]

Technology [2]	# FSs Where Technology Considered	# FSs Tech. Passed Screening	# FSs Tech. Screened Out	Tech. Not Primary Component of Alternative	#FSs Where Criterion Contributed To Screening Out [3]: Cost	Effectiveness	Implement	# RODs Tech. Selected	# RODs Tech. Not Selected	# RODs Where Criterion Contributed to Non-Selection: Protect	ARARs	TMV Through Treatment	Long-term Effect.	Short-term Effect.	Cost	Implem.	State Concerns [4]	Community Concerns [4]
Vibrating Beam	5	0	5	0	0	3	3	0	0	0	0	0	0	0	0	0	..	..
Liners	2	0	2	0	0	1	2	0	0	0	0	0	0	0	0	0	..	–
Offsite Nonhazardous Landfill	3	0	3	0	0	0	3	0	0	0	0	0	0	0	0	0	–	–
Offsite RCRA Landfill	17	0	13	4	8	3	12	0	0	0	0	0	0	0	0	0	..	–
Offsite Landfill (unspecified)	9	1	8	0	5	3	5	1	0	0	0	0	0	0	0	0	..	–
Onsite Nonhazardous Landfill	2	0	2	0	1	1	1	0	0	0	0	0	0	0	0	0	..	..
Onsite RCRA Landfill	14	1	11	2	3	2	10	0	1	0	0	0	0	0	0	1	..	..
Onsite Landfill (unspecified)	7	0	6	1	3	3	6	0	0	0	0	0	0	0	0	0	..	..
Bioremediation (unspecified)	13	0	13	0	0	13	1	0	0	0	0	0	0	0	0	0	..	..
Bioremediation Ex-situ	10	0	10	0	0	7	7	0	0	0	0	0	0	0	0	0	..	..
Bioremediation In-situ	15	1	14	0	1	13	7	1	0	0	0	0	0	0	0	0	..	..
Dechlorinization/ APEG	6	0	5	1	1	4	2	0	0	0	0	0	0	0	0	0	..	..
Oxidation/ Reduction	12	0	12	0	1	8	5	0	0	0	0	0	0	0	0	0	..	..

TABLE 1 • SUMMARY OF SCREENING AND DETAILED ANALYSIS FOR LANDFILLS (Continued)[1]

Technology [2]	# FSs Where Technology Considered	# FSs Tech. Passed Screening	# FSs Tech. Screened Out	Tech. Not Primary Component of Alternative	# FSs Where Criterion Contributed To Screening Out [3]: Cost	Effectiveness	Implement	# RODs Tech. Selected	# RODs Tech. Not Selected	# RODs Where Criterion Contributed to Non-Selection: Protect	AR/Rs	TMV Through Treatment	Long-term Effect.	Short-term Effect.	Cost	Implem.	State Concerns [4]	Community Concerns [4]
Neutralization	4	0	3	1	0	2	1	0	0	0	0	0	0	0	0	0	--	--
Thermal Destruction (unspecified)	6	0	6	0	0	3	4	0	0	0	0	0	0	0	0	0	--	--
Offsite Incineration (unspecified)	19	2	14	3	9	5	10	1	1	0	0	0	0	1	1	0	--	--
Onsite Incineration (unspecified)	12	0	8	3	5	5	6	0	1	0	0	0	0	1	1	1	--	--
Fluidized Bed	9	0	9	0	5	6	4	0	0	0	0	0	0	0	0	0	--	--
Infrared	8	0	7	1	6	3	3	0	0	0	0	0	0	0	0	0	--	--
Pyrolysis	5	2	3	1	2	2	1	0	1	0	1	0	0	1	1	1	--	--
Multiple Hearth	4	0	4	0	2	2	1	0	0	0	0	0	0	0	0	0	--	--
Rotary Kiln	10	0	9	1	6	5	4	0	0	0	0	0	0	0	0	0	--	--
Vitrification	21	0	21	0	8	15	11	0	0	0	0	0	0	0	0	0	--	--
Low Temperature Thermal Desorp/ Stripping	13	1	11	1	2	9	3	0	1	0	0	0	0	0	1	0	--	--
In-situ Steam Stripping	5	0	5	0	1	4	2	0	0	0	0	0	0	0	0	0	--	--
Soil Flushing	16	2	14	0	2	9	10	0	0	0	0	0	0	0	0	0	--	--

TABLE 1 • SUMMARY OF SCREENING AND DETAILED ANALYSIS FOR LANDFILLS (Continued)[1]

Technology [2]	# FSs Where Technology Considered	# FSs Tech. Passed Screening	# FSs Tech. Screened Out	Tech. Not Primary Component of Alternative	#FSs Where Criterion Contributed To Screening Out [3]			# RODs Tech. Selected	# RODs Tech. Not Selected	# RODs Where Criterion Contributed to Non-Selection								
					Cost	Effectiveness	Implement			Protect	ARARs	TMV Through Treatment	Long-term Effect.	Short-term Effect.	Cost	Implem.	State Concerns [4]	Community Concerns [4]
Soil Washing	12	2	9	1	1	8	6	0	0	0	0	0	0	0	0	0	--	--
Soil Vapor Extraction (SVE)	14	1	11	2	2	9	5	1	0	0	0	0	0	0	0	0	--	--
Fixation	7	1	5	1	0	4	2	2	0	0	0	0	0	0	0	0	--	--
Stabilization/ Solidification	20	0	19	2	1	13	6	0	0	0	0	0	0	0	0	0	--	--
Aeration	7	0	7	0	0	5	3	0	0	0	0	0	0	0	0	0	--	--

1 This study was conducted on 30 RODs and their corresponding FSs.
2 This does not the include the no-action or institutional control only alternatives. No RODs selected either of these as remedies.
3 FSs and RODs may contain more than one criterion for screening or non-selection of technology. Also, some FSs did not fully explain the criteria for screening out a technology. Thus, the totals for screening and non-selection criteria are not equal to the number of FSs and RODs considered.
4 Information on State and community concerns was not included in this analysis because FSs do not contain this information and RODs generally only reference supporting documentation (i.e., State concurrence letter and responsiveness summary).

THE WATAUGA COUNTY LANDFILL
PERMIT NO. 95-02

REMEDIAL INVESTIGATION AND ALTERNATIVES REPORT APPENDICES
TARGET PARAMETER TREND STATISTICS

Prepared for
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Board of Commissioners

and

North Carolina Department of Environment, Health and Natural Resources
Division of Solid Waste Management
Solid Waste Section

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